

The sand and gravel resources of the country around Dalkeith and Temple, Lothian Region

Description of 1:25 000 sheets NT 25 and 35, and NT 26 and 36

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The first twelve reports on the assessment of British sand and gravel resources appeared in the Report series of the Institute of Geological Sciences as a subseries. Report 13 and subsequent reports appear as Mineral Assessment Reports of the Institute.

Details of published reports appear at the end of this report.

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PREFACE

National resources of many industrial minerals may seem so large that stock-taking appears unnecessary, but the demand for minerals and for land for all purposes is intensifying and it has become increasingly clear in recent years that regional assessments of the resources of these minerals should be undertaken. The publication of information about the quantity and quality of deposits over large areas is intended to provide a comprehensive factual background against which planning decisions can be made.

Sand and gravel, considered together as naturally occurring aggregate, was selected as the bulk mineral demanding most urgent attention, initially in the south-east of England, where about half the national output is won and very few sources of alternative aggregates are available. In 1968, following a short feasibility study initiated in 1966 by the Ministry of Land and Natural Resources, the Industrial Minerals Assessment Unit (formerly the Mineral Assessment Unit) began systematic surveys which have been extended progressively through central and northern England. Work in Scotland, which began in 1975 in the Darvel area of Strathclyde Region, is being financed by the Department of the Environment, acting through the Scottish Development Department, and is being undertaken with the cooperation of the Sand and Gravel Association of Great Britain.

This report describes the resources of sand and gravel of 400km² of country lying mainly in Lothian Region, but including parts of Borders Region, and shown on the accompanying resource maps. The survey was conducted by A.M. Aitken, J.H. Lovell and A.J. Shaw, with assistance during the drilling investigation from S.C. Groves, J.W. Merritt and D.L. Ross. The work is based on the Peebles (24E), Galashiels (25W), Edinburgh (32E) and Haddington (33W) sheets of the 1:50000 Geological Map of Scotland, but incorporating a partial resurvey of the sand and gravel deposits during 1980 and 1981 by J.D. Floyd, P.M. Halpin, A.E.S. Kemp and J.L. Smellie.

The section of the report on the geology of the area was prepared by J.D. Floyd: the aggregate testing was undertaken by C.W. Thomas.

J.D. Burnell, ISO, FRICS (Land Agent), has been responsible for negotiating access to land for drilling; the ready cooperation of land owners, tenants and sand and gravel operators is gratefully acknowledged.

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The sand and gravel resources of the country around Dalkeith and Temple, Lothian Region

Description of 1:25 000 sheets NT 25 and 35, and NT 26 and 36

A. M. Aitken, J. H. Lovell, A. J. Shaw and C. W. Thomas

SUMMARY

The geological maps of the Institute of Geological Sciences, ninety eight boreholes and twenty nine shallow pits sunk for the Industrial Minerals Assessment Unit, together with pre-existing borehole information and data from working pits, form the basis of the assessment of sand and gravel resources in Dalkeith and Temple, Lothian Region.

All deposits in the area which might be potentially workable for sand and gravel have been investigated and a simple statistical method used to estimate the volume. The reliability of the volume estimates is given at the symmetrical 95 per cent probability level.

The 1:25000 maps are divided into seven resource blocks, six of which are assessed statistically and contain between 4.8 and 10.1km² of potentially workable sand and gravel. For the seventh resource block inferred assessments are offered for 5.2km² of mineral. The geology of the deposits is described and the mineral-bearing area the mean thickness of overburden and mineral, and the mean grading are stated. Detailed sample point data are given. The geology, the outlines of the resource blocks and the position of sample points used in the assessment are shown on the accompanying resource maps.

Bibliographic reference

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Note

National Grid references are given in square brackets. In this publication all lie within the 100-km square NT.

INTRODUCTION

The survey is concerned with the estimation of resources, which include deposits that are not currently exploitable but have a foreseeable use, rather than reserves, which can only be assessed in the light of current, locally prevailing, economic considerations. Clearly, both the economic and the social factors used to decide whether a deposit may be workable in the future cannot be predicted; they are likely to change with time. Deposits not currently economically workable may be exploited as demand increases, as higher grade or alternative materials become scarce, or as improved processing techniques are applied to them. The improved knowledge of the main physical properties of the resource and their variability which this survey seeks to provide will add significantly to the factual background against which planning policies can be decided (Archer, 1969; Thurrell, 1971, 1981; Harris and others, 1974).

The survey provides information at the 'indicated' level "for which tonnage and grade are computed partly from specific measurements, samples or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout" (Bureau of Mines and Geological Survey, 1948, p.15).

It follows that the whereabouts of reserves must still be established and their size and quality proved by the customary detailed exploration and evaluation undertaken by the industry. However, the information provided by this survey should assist in the selection of the best targets for such further work.

The following arbitrary physical criteria have been adopted:

- a The deposit should average at least 1m in thickness.
- b The ratio of overburden to sand and gravel should be no more than 3:1.
- c The proportion of fines (particles passing the No.240 mesh BS sieve, about $\frac{1}{2}$ mm) should not exceed 40 per cent.
- d The deposit must lie within 25m of the surface, this being taken as the likely maximum working depth under most circumstances. It follows from the second criterion that boreholes are drilled no deeper than 18m if no sand and gravel has been proved.

A deposit of sand and gravel which broadly meets these criteria is regarded as 'potentially workable' and is described and assessed as 'mineral' in this report. As the assessment is at the indicated level, parts of such a deposit may not satisfy all the criteria.

For the particular needs of assessing sand and gravel resources, a grain-size classification based on the geometric scale $\frac{1}{2}$ mm, $\frac{1}{4}$ mm, 1mm, 4mm, 16mm has been adopted. The boundaries between fines (that is, the clay and silt fractions) and

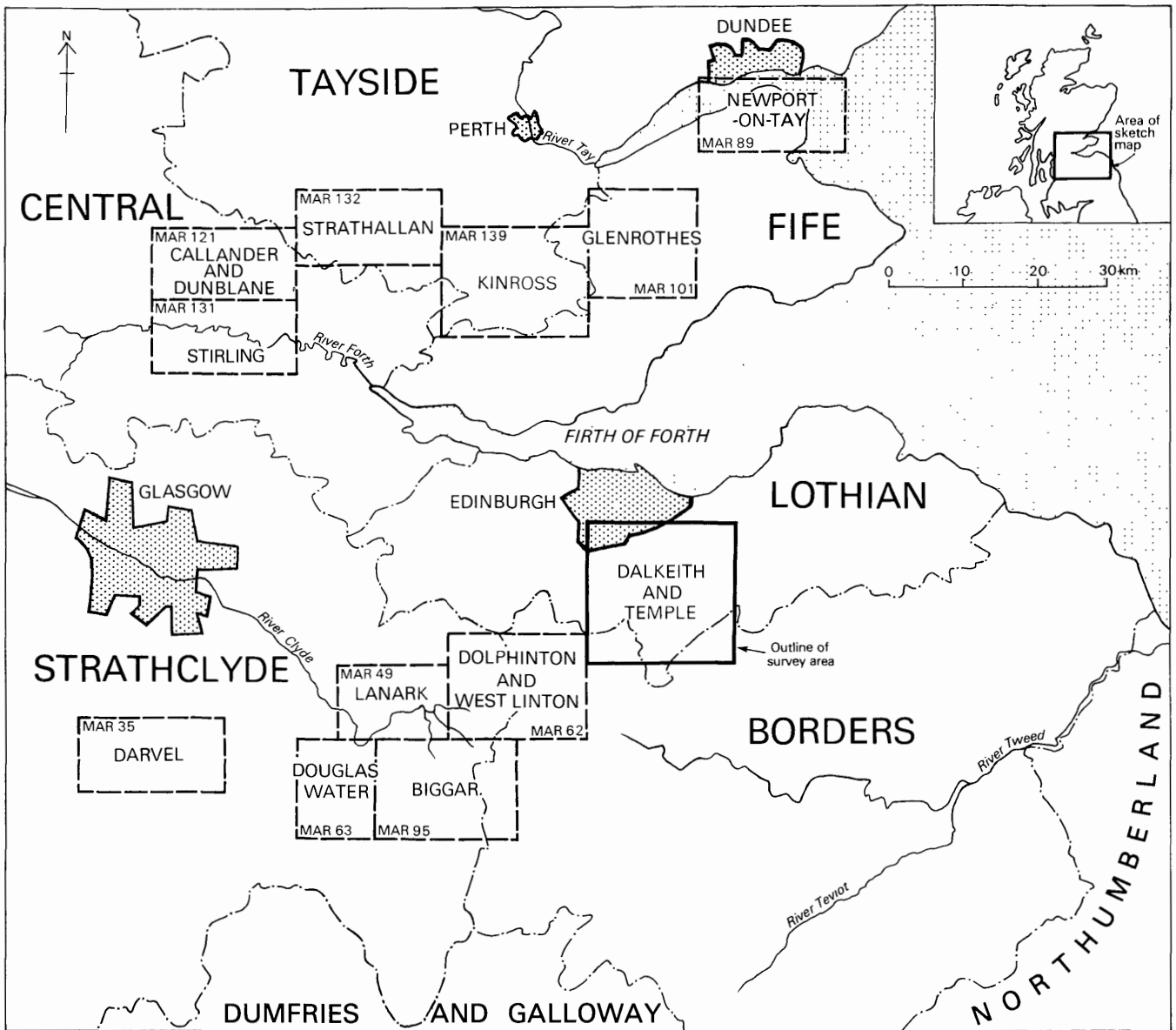


Figure 1 Sketch-map showing the location and limits of the published resource sheets in the south of Scotland

sand, and between sand and gravel material, are placed at $\frac{1}{2}$ mm and 4mm respectively (see Appendix C).

The volume and other characteristics are assessed within resource blocks, each of which, ideally, contains approximately 10km² of sand and gravel. No account is taken of any factors, for example, roads, villages and high agricultural or landscape value, which might stand in the way of sand and gravel being exploited, although towns are excluded. The estimated total volume therefore bears no simple relationship to the amount that could be extracted in practice.

It must be emphasised that the assessment applies to the resource block as a whole. Valid conclusions cannot be drawn about the mineral in parts of a block, except in the immediate vicinity of the actual sample points.

DESCRIPTION OF THE RESOURCE SHEET

GENERAL

The resource sheet area covers 400km² of country on the south-eastern side of Edinburgh and includes the towns of Dalkeith and Penicuik and

the villages of Temple, Gorebridge, Newtongrange, Loanhead, Bonnyrigg and Lasswade, as well as part of the suburbs of Edinburgh (Figures 1 and 2). The land outside the urban developments is mainly given over to mixed farming, with some forestry and sheep husbandry on the higher ground. Peat is extracted commercially from Auchencorth Moss [20 53].

The Carboniferous sediments that underlie much of the area have been extensively worked for coal, limestone, ironstone, fireclay, oil shale and shale for brickmaking; all such workings have now ceased except for the National Coal Board mine at Bilston Glen [271 651], a small private coal mine at Temple [313 587], the limestone quarry at Middleton [356 583] and the quarry for brickmaking shale at Newbigging [268 598].

The sand and gravel resources cover 54km² or about 14 per cent of the survey area. They were first described systematically by Haldane (1948) and Goodlet (1970). More recently, McAdam (1977, 1978) has summarised published and unpublished data on the deposits in Borders and Lothian regions. Assessments of resources in the adjacent Lanark, Dolphinton and West Linton, Douglas Water and Biggar areas are published in

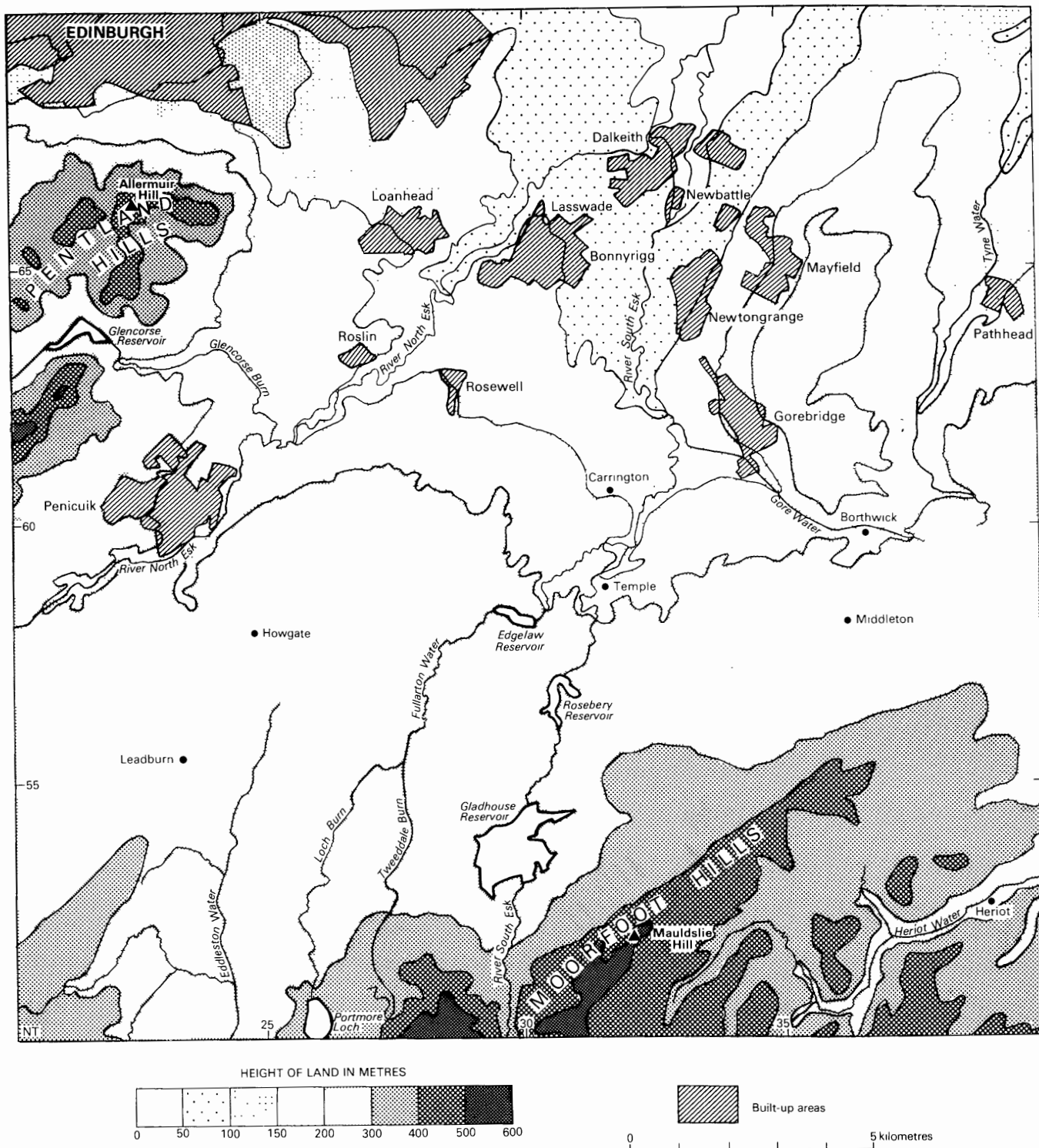


Figure 2 Sketch-map showing topography and localities

Mineral Assessment Reports 49, 62, 63 and 95 respectively (Laxton and Nickless, 1980; McMillan, Laxton and Shaw, 1981; Shaw and Nickless, 1981; Shaw and Merritt, 1982).

There are currently four pits working sand and gravel in the area. These are at Melville [298 665] and Haverall Wood [292 661], near Lasswade, Cowieslinn [239 515] and Ship Horns [241 501], south of Leadburn. Most of the material is destined for markets in the Edinburgh area.

TOPOGRAPHY

Topographically the area is dominated by the Moorfoot and Pentland Hills (Figure 2). Much of

the upland exceeds 300m above OD: most of the sand and gravel-bearing area lies below this height. In the main the drainage is northwards or north-eastwards into the Forth Estuary via the rivers North and South Esk and the Tyne Water. The River North Esk, in particular, is deeply incised above its confluence with the River South Esk. The valley of the Tyne Water is now occupied by a misfit stream, a consequence of river capture near Borthwick [371 597] of the Middleton North and Middleton South burns by the Gore Water, a tributary of the River South Esk. In the south of the resource-sheet area the Eddleston Water flows southwards to meet the Tweed at Peebles, and the Heriot Water joins the Gala Water.

GEOLOGY

The resource-sheet area falls within the Peebles (24E), Galashiels (25W), Edinburgh (32E) and Haddington (33W) sheets of the 1:50000 Geological Map of Scotland. The area was originally geologically surveyed at a scale of six inches to one mile by A. Geikie, J. Geikie, B.N. Peach, A.C. Ramsay, H.H. Howell and J. Young and published at the one-inch scale between 1859 and 1879. Drift lines for the upland areas of the resource sheet have been taken from resurveys between 1872 and 1970 by B.N. Peach, J. Horne, H.E. Wilson, T. Robertson, H.S. Walton, J.B. Simpson, W. Mykura and W. Tulloch. In connection with the present investigation, the sand and gravel deposits were resurveyed during 1980-82 by J.D. Floyd, P.M. Halpin, A.E.S. Kemp and J.L. Smellie.

Over much of the assessment area, Quaternary deposits comprising till, glacial meltwater deposits, alluvium and peat overlie a variety of rock types, which range from Ordovician to

Carboniferous in age. The term glacial meltwater deposits includes glacial sand and gravel, fluvioglacial sand and gravel and glaciolacustrine deposits. The geological sequence is summarised in Table 1, where deposits are listed, as far as possible, in order of increasing age.

Solid

A sketch-map of the solid geology is shown in Figure 3. The oldest rocks, which crop out to the south-east of the Southern Upland and Lammermuir faults, are of Ordovician age and include shale, red and black chert, spilitic lava, greywacke and conglomerate. They were deposited within a deep, elongate basin, the axis of which was oriented in a north-easterly direction.

During the Caledonian orogeny, at its most intense in late Silurian and early Devonian times, these rocks were folded and faulted along a north-easterly (Caledonoid) trend and finally uplifted to form the Southern Uplands, which have remained a positive feature from Devonian times to the present day.

Forming part of the Pentland Hills to the north-west of the Pentland Fault, a small area of greenish conglomerate belonging to the Lower Old Red Sandstone occurs associated with a thick sequence of contemporaneous andesitic and basaltic lava. Numerous minor felsitic intrusions cut the lavas of the Pentland Hills.

A period of uplift, gentle folding and erosion occurred prior to deposition of the red-brown sandstones of the Upper Old Red Sandstone Formation which crop out in the Colinton area [221 689] and unconformably overlie the Lower Old Red Sandstone lavas.

In the north-western part of the area the succeeding Calciferous Sandstone Measures of Carboniferous age are subdivided into three groups, namely, the Cementstones, the Lower Oil Shales and the Upper Oil Shales. The Cementstone Group crops out only near Colinton, where it consists of sandstone conformably overlying the Upper Old Red Sandstone. Lower Oil Shale Group sediments consist of sandstone, mudstone and a few oil shales. They crop out in the Colinton area and in a small strip on the south-eastern side of the Pentland Fault. Sediments of the Upper Oil Shale Group crop out in a long strip on the south-eastern side of the Pentland Fault and consist of mudstone, sandstone, thin limestone and several oil shales, some of which were formerly mined hereabouts. Undivided Calciferous Sandstone Measures sediments occur along the southern margins of the resource-sheet area between Howgate [248 580] and Borthwick [369 596]. The Cementstone and Lower and Upper Oil Shale Group sediments were laid down in shallow lagoonal bodies of brackish water subjected to infrequent marine incursions which became more common through time.

A widespread marine transgression marks the base of the Lower Limestone Group and the strata of this subdivision were deposited in marine and deltaic environments. The sediments comprise cyclic sequences of limestone, sandstone, mudstone and some thin coal seams. During succeeding Limestone Coal Group times, shallower deltaic conditions prevailed and numerous thick coal seams were laid down in a mixed succession of sandstone and mudstone with rare marine shell beds. A return to an alternating marine and deltaic environment took place in Upper Limestone Group times, represented in this area by thick sandstones along with a few thin marine limestones and infrequent, mostly thin, coals.

Much of the Passage Group consists of sandstone, in part coarse grained and feldspathic,

Table 1 Geological classification of the deposits

DRIFT

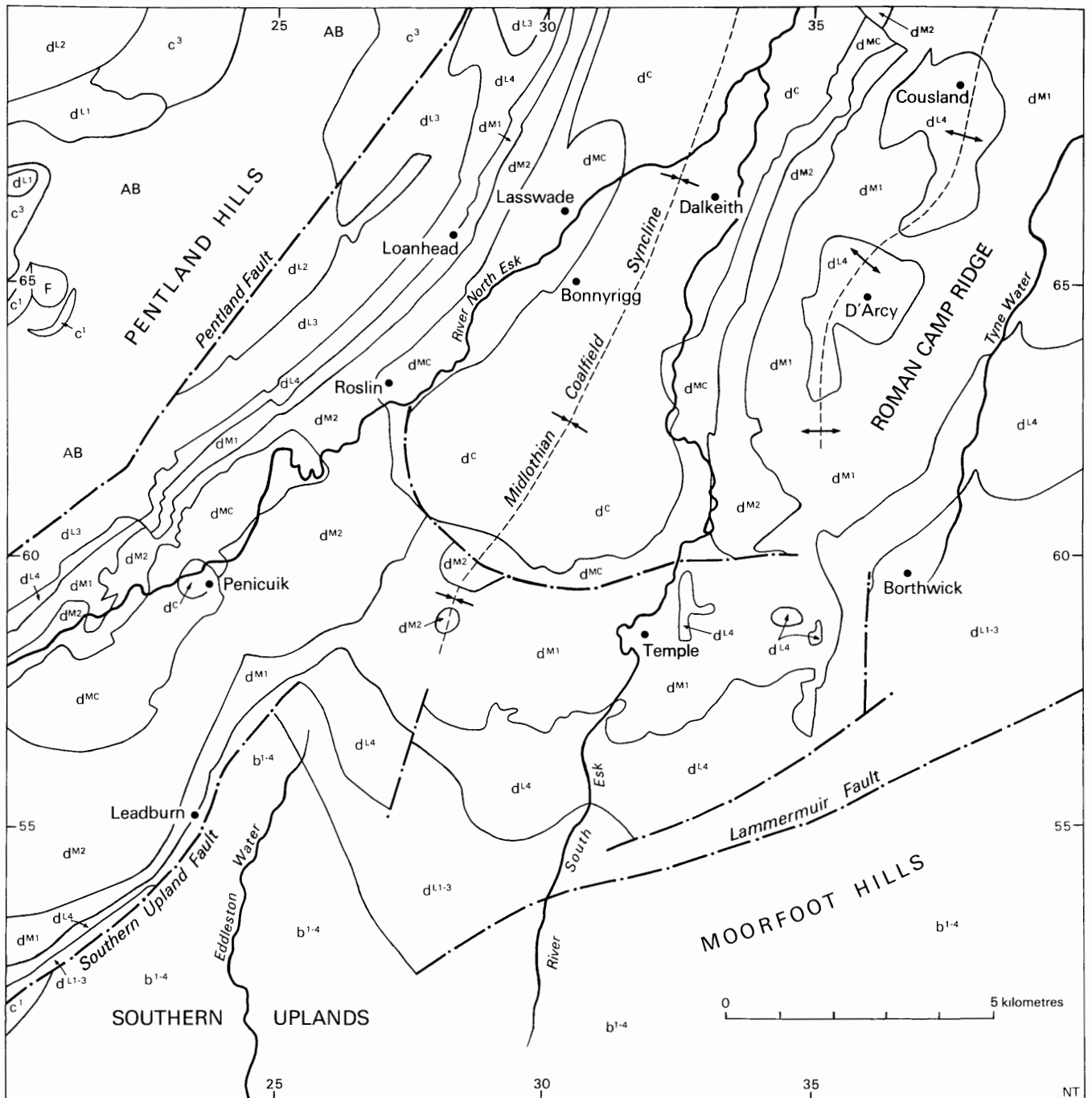
Quaternary

Peat
Alluvium
Raised beach deposits
and associated
estuarine alluvium,
late- to post-Glacial
in age
"Roslin Till"
Fluvioglacial sand and
gravel
Glacial sand and gravel
Glaciolacustrine
deposits
Till

SOLID

Carboniferous

Coal Measures	Thick coal seams, sandstone and mudstone, reddened at top
Passage Group	Sandstone and conglomerate
Upper Limestone Group	Thick sandstone with a few thin limestone and coal seams
Limestone Coal Group	Thick coal seams, sandstone and mudstone
Lower Limestone Group	Limestone, sandstone, mudstone and a few coal seams
Upper Oil Shale Group	Mudstone, sandstone, thin limestone and oil shale
Lower Oil Shale Group	Sandstone, mudstone and oil shale
Cementstone Group	Mudstone and sandstone
Upper Old Red Sandstone	Sandstone
Lower Old Red Sandstone	Conglomerate, andesitic and basaltic lava and minor felsitic intrusions
Ordovician	Greywacke, conglomerate, shale, chert and spilitic lava



SEDIMENTARY ROCKS

CARBONIFEROUS

- d^C Coal Measures
- d^{MC} Passage Group
- d^{M2} Upper Limestone Group
- d^{M1} Limestone Coal Group
- d^{L4} Lower Limestone Group
- d^{L3} Upper Oil Shale Group

- d^{L2} Lower Oil Shale Group
- d^{L1} Cementstone Group
- d^{L1-3} Califerous Sandstone Measures (undivided)

OLD RED SANDSTONE

- c³ Upper Old Red Sandstone
- c¹ Lower Old Red Sandstone

ORDOVICIAN

- b¹⁻⁴

IGNEOUS ROCKS

- F Felsite intrusion
- AB Rhyolite, trachyte, andesite and basalt lava with tuff bands

- Geological boundary
- Major faults
- Axis of syncline
- Axis of anticline

Figure 3 Sketch-map of the solid geology

indicating a dominantly deltaic environment. Conglomerates are present in places resting on eroded surfaces of the underlying beds.

During the succeeding Coal Measures epoch, conditions were similar in many respects to those prevailing during the deposition of the Limestone Coal Group. Thick coal seams indicate prolonged accumulation of vegetation under swamp conditions. Marine incursions occurred very rarely, though fossils of brackish water bivalves are common above several coal seams. Sediments near the top of the Coal Measures, the youngest solid strata found in the area, have suffered severe secondary reddening involving the destruction or carbonation of coal seams during desert conditions in late Carboniferous or Permo-Carboniferous times.

The disposition of most Carboniferous strata in the area is controlled by the Midlothian Coalfield Syncline, a broad northward-plunging structure, and the associated D'Arcy-Cousland Anticline, which forms the Roman Camp Ridge, on its eastern flank.

Drift

During the Quaternary the area was glaciated on several occasions but the last or Devensian glaciation has probably obliterated any deposits of earlier phases of glacial activity. At the peak of the Devensian glaciation, an ice sheet emanating from the Scottish Highlands advanced across the northern part of the area from west to east. At the same time, ice derived from the Southern Uplands moved north-eastwards along the gap between the Pentland and Moorfoot hills to coalesce with the Highland ice and move eastwards towards the North Sea. The basal lodgement till left by these ice sheets is generally confined to the lower ground and usually thins towards the hills. Its composition is variable but often shows a close relationship to the rocks over which the ice moved. Over most of the Midlothian Coalfield, the basal till is a stiff, grey clay containing mainly small stones with rare large boulders up to about 1.8m in diameter. Where the underlying bedrock contains a high proportion of sandstone, the till is very sandy. Apart from a high proportion of Carboniferous sediments, such as sandstone, limestone, mudstone, ironstone, chert and coal, the clast content includes a varied suite of igneous rocks and a small percentage of Highland erratics. In the southern part of the resource-sheet area greywacke and other rocks of Pentland Hills and Southern Uplands origin form a high proportion of the clasts. On the basis of pebble count studies, and with supporting evidence from rare interbedded sand and gravel, Kirby (1968) proposed that the till can be subdivided into a lower component deposited by Highland ice, and an upper component deposited by Southern Uplands ice. But over most of the resource-sheet area only a single basal till can be recognised, and in a recent detailed study of the area Martin (1981) considered that all the features of the basal till can be accounted for by a single ice sheet. Nevertheless, a borehole at Heriot [390 526] indicated the presence of four tills, one of which was dominated by clasts of Carboniferous sediments, implying that on at least one occasion the Moorfoot Hills were overwhelmed by glacial ice from the north.

As the climate ameliorated, the ice sheet halted its advance and began to thin and melt *in situ*, the tops of the higher hills being the first areas to become ice-free. Increasing volumes of meltwater formed lakes and drainage systems with streams flowing below, within, on top of and on the margins of the melting ice sheet. The

extensive deposits of silt, sand and gravel in the Midlothian Basin were laid down during this period, frequently as deltas in lakes impounded by ice occupying the Forth Estuary to the north. The deposits give rise to a variety of surface forms such as terraces, kames (mounds), kettle holes (depressions left by melting of isolated, buried blocks of ice) and eskers (long sinuous ridges). In the upper part of the valley of the Eddleston Water meltwater laid down an extensive, thick pile of sand and gravel which for a time impeded drainage to the south and caused the present-day Eddleston Water to excavate a new route between the deposit and the east side of the valley.

Adjacent to the Moorfoot Hills the gravels contain a high proportion of greywacke pebbles derived from the Southern Uplands. As far north as Howgate and Borthwick greywacke is still the most common single component of the gravels. Northwards the gravels contain increasing quantities of pebbles derived from the underlying Carboniferous rocks, notably sandstone, and igneous rocks originating mainly from the Pentland Hills.

In the Loanhead-Roslin area [27 64], corresponding with the area coloured light red on the northern resource sheet, the fluvioglacial sands and gravels are overlain by the so-called "Roslin Till" (Kirby, 1968), a reddish brown stony clay which also lies directly on the basal till in places. It has been variously interpreted as the lodgement till of a re-advance of ice from the Southern Uplands (Mitchell and Mykura, 1962) and from the north (Kirby, 1968). However, Martin (1981) concluded that the Roslin Till was probably deposited by "debris flows" and is not the product of an ice sheet re-advance. A similar deposit, also resting on fluvioglacial sands and gravels, has been recorded during the present investigation near Coates [217 609], in the Temple area between Carrington [319 605] and Yorkston [315 566] and north of Borthwick.

Numerous glacial drainage channels cut in rock, till and gravel were formed at different stages during the melting of the ice sheet. Many channels are oriented approximately east-west, parallel to the ice margin, and were excavated by glacial meltwaters at a time when the most direct northerly escape route was still blocked by the decaying ice sheet.

Since the ice finally melted about 12500 years ago the glacial deposits have been partly eroded, transported and redeposited as alluvium during the development of the present drainage system. In the extreme north of the resource-sheet area fluvioglacial sands and gravels were reworked during a period of high sea level to form raised beach deposits in the valley of the River Esk, north of Dalkeith. On the high ground south of Penicuik several large areas of peat formed, the most extensive being that of Hare Moss [20 56].

COMPOSITION OF THE MINERAL DEPOSITS

On the basis of observed morphology and grading, the sand and gravel deposits of the survey area can be classified into three main types: fluvioglacial sand and gravel, glacial sand and gravel and alluvium. Although less common, deposits of sand and gravel are also found in the till and in the glaciolacustrine deposits. These groups are used as the basis for the description of the composition of the sand and gravel. Detailed particle-size distribution information is given in Tables 9 to 15. Figures 4 to 8 display graphically the cumulative mean grading and size frequency distribution for each category of

deposit. The envelope within which the cumulative mean gradings of deposits from individual boreholes lie is also shown.

Fluvioglacial sand and gravel Fluvioglacial sand and gravel underlies terraces in the valleys of the rivers North Esk and Tyne. The deposits in the valley of the Tyne Water extend from south of Borthwick to Temple [317 586]. In the area between Auchendinny [255 621], Loanhead [233 656] and the Pentland Hills laterally extensive deposits of fluvioglacial sand and gravel up to at least 20m thick occur beneath the Roslin Till. Fluvioglacial deposits are also covered by thin till in the area between Carrington and Temple.

Pebble counts of the fluvioglacial gravels are given in Table 3. Overall, the fluvioglacial sand and gravel has a mean grading of fines 11 per cent, sand 64 per cent and gravel 25 per cent (Figure 4). The deposits range in classification from 'very clayey' sand to gravel (for definition of terms see Appendix C); some cobbles may be present.

In the area between Penicuik [238 598] and Bonnyrigg [316 653] commonly thick sand sequences are overlain by gravel and sandy gravel. From Bonnyrigg north-eastwards the deposits become thinner and generally comprise gravel, though sand may predominate in places. Fluvioglacial sand and gravel in the valley of the Tyne Water becomes generally more sandy downstream. The most gravelly deposits occur in the area between Carrington and Temple, though north of Pathhead [394 644] the deposits once more become gravel-rich.

The sand fraction is generally quartz-rich but also contains some lithic fragments, coal and feldspar grains. Fines occur either as thin seams of silt and clay or are disseminated throughout the coarser fractions.

Glacial sand and gravel Hummocky and mounded deposits of glacial sand and gravel occur mainly in the area south and west of Temple and south and west of Penicuik. Small isolated patches are

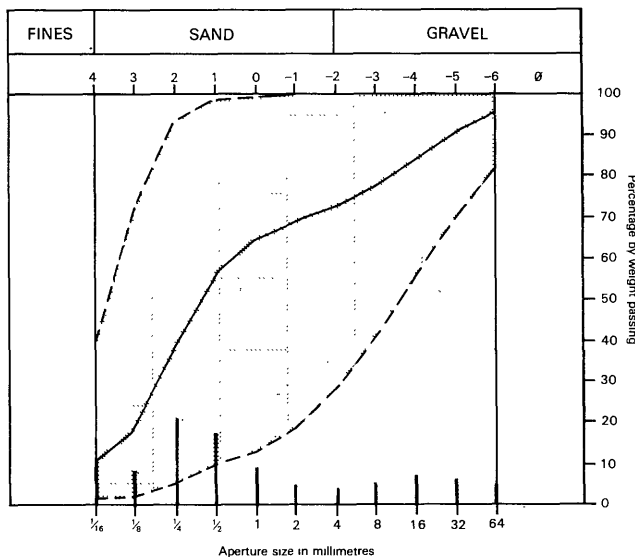


Figure 4 Grading characteristics of resources in the fluvioglacial sand and gravel. The shaded area defines the envelope within which the cumulative mean gradings of the mineral proved at individual sample points fall; the centre line represents the cumulative mean; the frequency distribution of the mean grading ($\frac{1}{16}$ to 64 mm) is represented by the bar graph

found along the south-eastern side of the Pentland Hills and extend into the southern outskirts of Edinburgh; a few isolated areas of glacial sand and gravel also occur on the valley sides of the Tyne Water. This deposit has also been identified beneath alluvium in the valley of the Heriot Water.

In the Temple area to the north-west of the Moorfoot Hills greywacke is abundant, other constituents being poorly represented. The gravel that occurs beneath alluvium in the valley of the Heriot Water is predominantly composed of greywacke. This, together with a high content of flaky mudstone clasts (14 per cent), indicates a local origin for the deposit because the clasts have suffered little abrasion. The sand fraction is mainly quartz, though lithic fragments are present. Fines occur as disseminated silt and clay.

Overall, the deposit has a mean grading of fines 12 per cent, sand 52 per cent and gravel 36 per cent. Some cobble gravel may be present. The range of grading within the deposit (Figure 5) is from 'very clayey' sand to gravel with a low fines content. Glacial sand and gravel as sampled is similar to the fluvioglacial sand and gravel in terms of mean grading characteristics, though it is 12 per cent more gravel-rich. The mean fines contents are virtually identical. In the areas where only patchy deposits of glacial sand and gravel occur there is no observed systematic variation in grading characteristics from one deposit to another. South of Temple, where glacial sand and gravel occurs more extensively, the deposit is predominantly gravel-rich. Between Penicuik and Mount Lothian [272 569] and between Gladhouse Reservoir [300 535] and Chester Hill [342 562] the deposits are more sandy and may be of appreciable thickness, as in borehole 25 NW 80.

Alluvium The most continuous spreads of alluvium are confined to the valleys of the Heriot Water and its tributaries in the extreme south-east of the resource sheet area, and to the valley of the Tyne Water. The valleys of the rivers North and South Esk contain only scattered deposits of alluvium; although a number of terrace levels have been identified, these are often erosive features, especially north of Newbottle [332 658] and

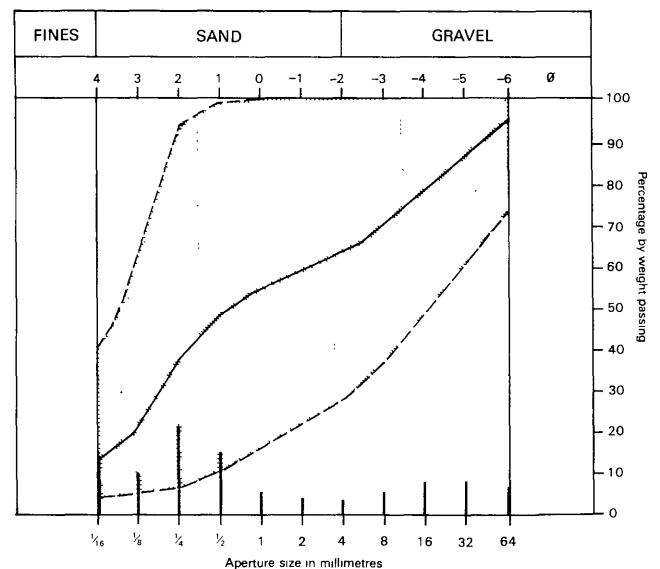


Figure 5 Grading characteristics of resources in the glacial sand and gravel; for explanation see Figure 4

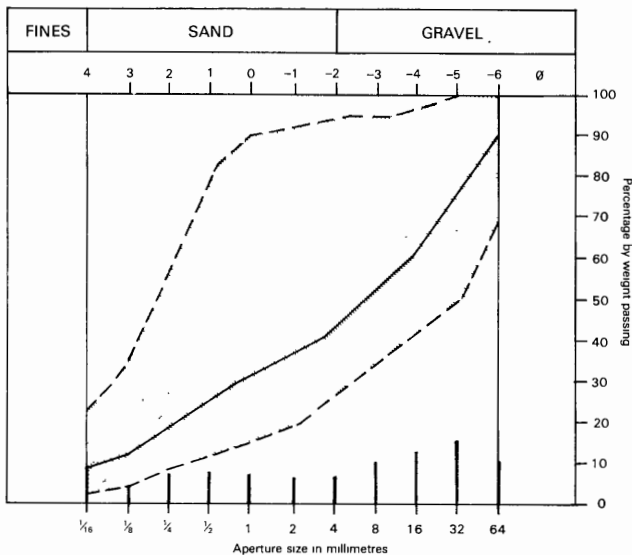


Figure 6 Grading characteristics of resources in the alluvium; for explanation see Figure 4

Bonnyrigg. Elsewhere alluvium is patchily developed adjacent to streams at and south of Temple. Some laterally extensive areas of alluvium are found at the north-eastern end of the Pentland Hills in Colinton [220 690] and west of Loanhead.

Samples of alluvium taken from the valley of the Heriot Water during this survey grade as mineral. Boreholes, for example 36 NW 343, drilled in alluvium of river valleys in other parts of the survey area indicate that these deposits are locally potentially workable. Because of the limited extent of the alluvium in relation to the scale of the assessment survey it has not been possible to investigate the deposits systematically.

Potentially workable alluvium has an overall mean grading of fines 8 per cent, sand 35 per cent and gravel 57 per cent (Figure 6). It ranges from 'very clayey' pebbly sand to gravel, in which about 30 per cent of the deposit may exceed 64mm.

The alluvium in the valley of the Heriot Water is greywacke-rich and has a relatively high mudstone content, the material being locally derived. Field observations suggest that else-

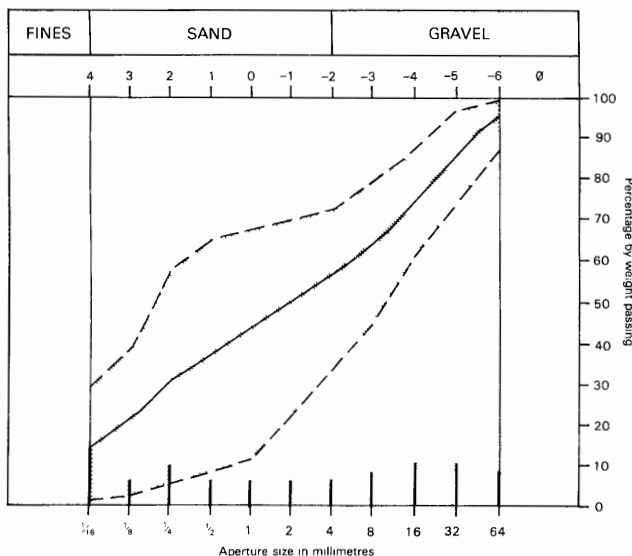


Figure 7 Grading characteristics of resources in the till; for explanation see Figure 4

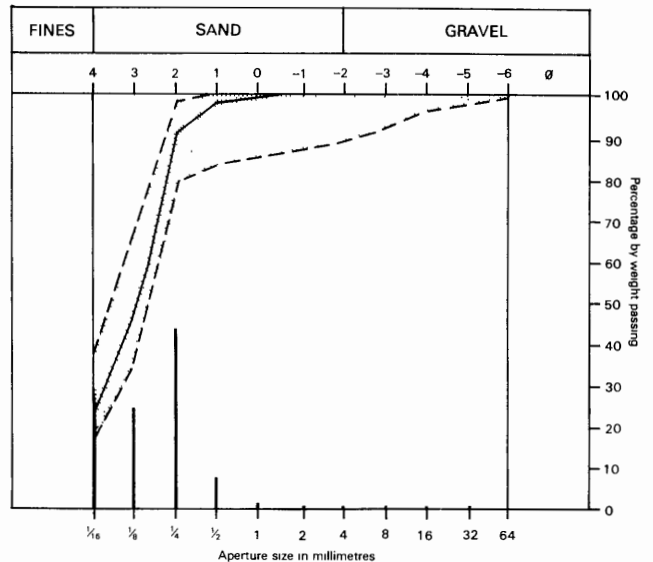


Figure 8 Grading characteristics of resources in the glaciolacustrine deposits; for explanation see Figure 4

where alluvium can be expected to have a gravel composition similar to that for neighbouring sand and gravel deposits. The sand fraction consists of lithic fragments, quartz and some coal.

Till Till is widely distributed over the resource-sheet area, but, probably because it was never deposited there, it is absent from the higher parts of the Pentland and Moorfoot hills and on the highest parts of the Roman Camp Ridge, from Gorebridge [346 613] to beyond Cousland [378 684]. In the valleys of the rivers North and South Esk and their tributaries, any till which was present has subsequently been largely removed by rivers cutting down through the drift deposits. Bedrock is commonly exposed in these incised valleys, especially in the valleys south of Bonnyrigg and Newtongrange, where alluvial deposits are generally absent.

Locally boreholes prove the till to comprise a potential resource with a mean grading of fines 15 per cent, sand 42 per cent and gravel 43 per cent (Figure 7). The range includes material classified as 'very clayey' pebbly sand to gravel. The lithologies contained in the gravel fraction, and in the till in general, are essentially similar to those found in the major sand and gravel deposits, except that there is a tendency for the local bedrock to exert a greater influence on the clast composition of the till.

Glaciolacustrine deposits A number of boreholes across the resource-sheet area encountered deposits which, on the basis of abundance of material finer than 0.125mm (normally more than 80 per cent of the deposit), are considered to have been formed in ice-dammed lakes. The deposits are mainly of clay and silt (with seams of fine sand) but locally they comprise 'very clayey' sand and as such form a potential resource which has a mean grading of fines 23 per cent, sand 77 per cent with a trace of fine gravel (Figure 8). The categories of deposit present are more restricted than for other potentially workable material, ranging from 'very clayey' sand to 'clayey' pebbly sand.

PETROGRAPHY, MECHANICAL AND PHYSICAL PROPERTIES OF THE AGGREGATE

Aggregate impact value (AIV), aggregate crushing value (ACV), 10 per cent fines value, relative density (on oven-dried and surface-dried bases), apparent relative density and water absorption were determined in accordance with BS 812:1975 for a selection of samples representing the major deposits of sand and gravel within the survey area. The aggregate impact value residue (AIVR) and aggregate crushing value residue (ACVR), as defined by Ramsay (1965) and Dhir and others (1971), were also determined. Composition analyses (pebble counts) were conducted on the samples in an attempt to relate differences in test results to the gravel lithologies.

The pebble counts, mechanical and physical tests were undertaken using 10- to 14-mm size material (BS 812.1:1975). In order to provide sufficient material for the range of tests, samples from boreholes and working pits were combined as necessary. The sources of the composite samples are given in Table 2. All material was washed and oven-dried before testing, in accordance with BS 812.3:1975. The geographical distribution of the boreholes from which samples were taken is shown in Figure 9.

Gravel composition The pebble count data are given in Table 3. Sedimentary rocks are the most abundant lithologies and always comprise more than 60 per cent of the total: sandstone and greywacke

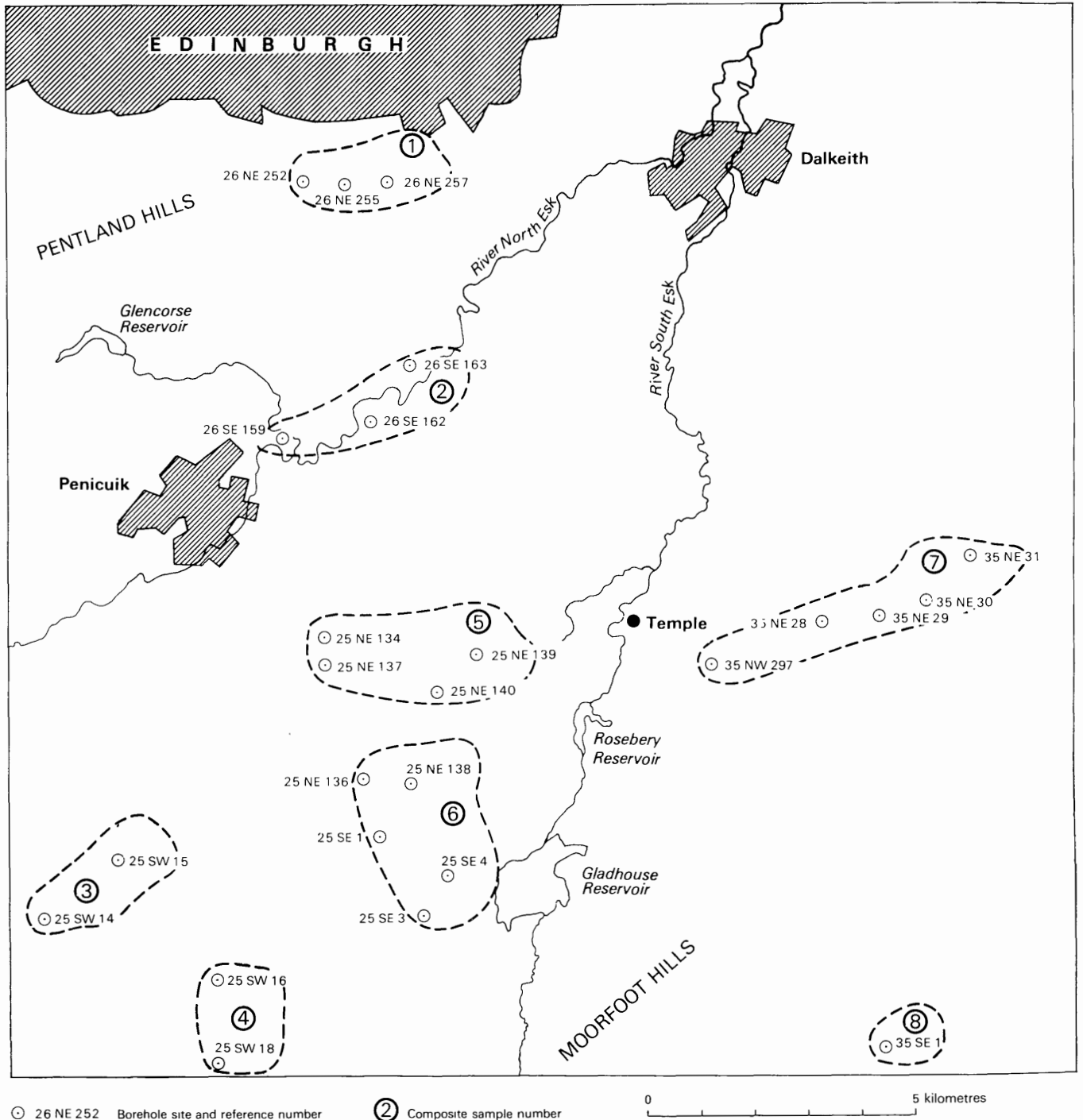


Figure 9 Location of boreholes from which aggregate was obtained for mechanical and physical testing. (The pecked lines enclose the boreholes from which composite samples were prepared and do not have any geological significance)

Table 2 Sources and geological classification of composite test samples

Composite Sample Number	Geological classification of deposit	Boreholes and working pits from which samples were taken	Depth range (m)
1	Glacial sand and gravel and fluvioglacial sand and gravel	26 NE 252	0.3 - 4.3
		26 NE 255	4.2 - 16.1
		26 NE 257	5.0 - 7.0
2	Fluvioglacial sand and gravel	26 SE 159	0.3 - 6.6
		26 SE 162	0.3 - 15.7
		26 SE 165	0.4 - 10.7
3	Glacial sand and gravel	25 SW 14	0.2 - 6.2
		25 SW 15	0.3 - 4.5
4	Glacial sand and gravel	25 SW 16	3.0 - 4.0
		25 SW 18	0.3 - 4.7
		Nether Falla Shiphorns	Face Face
5	Glacial sand and gravel and fluvioglacial sand and gravel	25 NE 134	0.3 - 12.5
		25 NE 137	1.5 - 10.6
		25 NE 139	15.7 - 18.1
		25 NE 140	0.2 - 1.7 5.2 - 6.2 0.3 - 6.7
6	Glacial sand and gravel	25 NE 136	0.2 - 2.8
		25 NE 138	0.1 - 5.1
		25 SE 1	0.2 - 6.8
		25 SE 3	1.0 - 6.2
		25 SE 4	0.2 - 4.3
7	Fluvioglacial sand and gravel	35 NW 297	0.4 - 8.8
		35 NE 28	5.2 - 10.3
		35 NE 29	0.3 - 9.7
			15.0 - 17.1
		35 NE 30	0.3 - 3.3
		35 NE 31	0.5 - 5.5 7.5 - 8.6
8	Alluvium and glacial sand and gravel	35 SE 1	0.3 - 10.5

are the most dominant lithologies; mudstone and fine to medium grained igneous rocks, including basalt, andesite and felsite are less common. The volcanic component generally comprises sub-equal amounts of andesite and basalt, although one may considerably exceed the other, as in samples 2, 5 and 6; however, it was sometimes difficult to distinguish these rock types in hand specimen. Other rock types, including porphyry, quartzite, grits, chert and vein-quartz, with rare coal, limestone and ironstone, comprise the bulk of the remainder. Metamorphic and coarse grained igneous rocks are rare.

It is evident from the pebble counts and from field observations that proportions of the predominant rock types (sandstone, greywacke and volcanic rocks) in the sand and gravel deposits are influenced by the local bedrock geology. The Moorfoot Hills and, more generally, the north-eastern part of the Southern Uplands are composed mainly of Lower Palaeozoic greywackes. The adjacent fluvioglacial sand and gravel and the glacial sand and gravel deposits (especially) are correspondingly greywacke-rich. This is also true of the deposits of alluvium and glacial sand and gravel in the valley of the Heriot Water.

Volcanic rocks derived from the Pentland

Hills influence the composition of deposits found on the north-west and towards the centre of the Esk Basin, where the gravels contain a noteworthy proportion of volcanic rocks and the greywacke content is much reduced. The sandstone component of these deposits is also much higher than in deposits in the south-east of the resource-sheet area, the sandstones being derived from Devonian and Carboniferous strata, both of which crop out locally.

On the basis of the pebble count data, the composite samples can be subdivided into three main groups. Samples 1,2,3,5 and 7 (Group 1) are characterised by greywacke (18 to 54 per cent), sandstone (18 to 32 per cent) and volcanic rocks (11 to 25 per cent). Generally, small amounts of limestone are present, although sample 1 containing 7 per cent is exceptional. Samples 4 and 6 (Group 2) contain abundant greywacke (77 and 84 per cent respectively). Argillaceous clasts (hereinafter referred to as mudstone) comprise 11 and 5 per cent of the total, but other lithologies individually never exceed 5 per cent. Compared with the previous group, sandstones are poorly represented. Although having many similarities to samples 4 and 6, sample 8 (Group 3) is considered to be distinct. The sandstone content is slightly

Table 3 Pebble counts of composite test samples 1 to 8 (+10-14mm size fraction)
(For origin of samples see Table 2).

Composite sample number		1	2	3	4	5	6	7	8
British Standard Trade Group	Rock type								
Basalt(2)*	Basalt	9	7	9	3	4	4	5	1
	Andesite	9	18	8	1	9	1	6	-
	Total, undivided	18	25	17	4	13	5	11	1
Flint (3)	Chert	**	1	3	2	3	2	2	**
Gabbro (4)	Gabbro	4	2	-	-	1	-	1	-
	Dolerite	**	3	2	-	2	1	-	-
	Total, undivided	4	5	2	-	3	1	1	-
Gritstone (6)	Greywacke	18	26	39	77	37	84	54	80
	Sandstone	32	18	19	2	27	1	21	4
	Grit	7	5	9	2	4	-	1	-
	Total, undivided	57	49	67	81	68	85	76	84
Limestone (8)	Undivided	7	1	1	-	**	-	**	-
Porphyry (9)	Undivided	5	10	2	**	1	**	1	-
Quartzite (10)	Quartzite	2	4	2	2	2	1	-	**
	Vein-quartz	1	4	1	1	1	1	3	1
	Total, undivided	3	8	3	3	3	2	3	1
Schist (11)	Pelite	**	1	-	-	1	-	-	-
Others	Mudstone	5	1	3	11	5	5	4	14
	Ironstone	1	**	3	-	1	-	-	-
	Coal	-	-	-	-	-	-	**	-
	Total, undivided	6	1	6	11	6	5	4	14
Number of pebbles counted		349	359	379	332	419	370	527	422

Results are given in frequency per cent. Calculations of weight per cent show close correlation.

* The numbers in parenthesis correspond with those used in BS 812.1:1975. Petrological groups 1, 5 and 7 are not represented here.

** Trace amounts (less than 0.5 per cent)

higher, as is the content of mudstone material, whereas the abundance of volcanic rocks and chert are rather lower. These lithological differences may appear to be slight, but mechanical and physical test results presented later indicate that they may have an important bearing on the properties of the aggregate and justify the distinction between samples 4 and 6 and sample 8.

Mechanical and physical properties - results For all composite samples except sample 3, for which no ACV test was undertaken, there was sufficient material for the full range of tests, listed above. The results are given in Table 4.

AIV, AIVR, ACV, ACVR and 10 per cent fines are tests of the strength of an aggregate. AIV is a relative measure of the resistance of an aggregate to sudden shock or impact. Resistance of an aggregate to applied compressive load is indicated by the ACV and 10 per cent fines results. In the ACV test the load is increased uniformly up to 400kN in ten minutes; in the 10 per cent fines test sufficient load is imposed to produce 10 per cent by weight of less than 2.36mm-sized material in ten minutes.

In considering the economic potential of an

aggregate, it is usually the ability of a clast to withstand impact (yet remain relatively intact) that is considered to be more important than its ability to withstand high levels of comminution. Ramsay (1965) and Dhir and others (1971) showed that this property of aggregates could be estimated by measuring the amount of the 10- to 14-mm fraction remaining after the test. Expressed as a percentage of the original mass, this gives the aggregate impact value residue (AIVR) and aggregate crushing value residue (ACVR) for the AIV and ACV tests respectively.

Aggregate strength depends on several petrographical features (Ramsay, 1965; Ramsay, and others, 1974). In igneous rocks, strength is governed by the degree of crystal interlocking, cleavage and the abundance of microfractures and twin planes. In sedimentary rocks, the strength of the intergranular cement governs the overall strength of aggregate clasts. The degree to which clasts are weathered is also considered to have an important effect on the strength of natural gravel aggregates.

The classification of the composite samples into three main groups on the basis of the pebble count data, is justified further by the results of

Table 4 Results of mechanical and physical tests BS 812.1:1975. Composite samples are grouped on the basis of the results

Composite sample	AIV (%)	AIVR (%)	ACV (%)	ACVR (%)	10% fines value (kN)	Relative density (oven-dried basis)	Relative density (surface-dried basis)	Apparent relative density	Water absorption	Group
1	26	34	20	43	170	2.42	2.52	2.68	3.8	1
2	22	37	18	43	190	2.42	2.51	2.65	3.6	
3	21	41	No test		200	2.42	2.52	2.69	4.1	
5	27	34	20	40	160	2.42	2.52	2.68	4.0	
7	23	38	18	43	200	2.42	2.53	2.68	3.6	
4	15	44	12	45	280	2.59	2.65	2.74	2.2	2
6	14	44	12	47	320	2.57	2.61	2.71	2.2	
8	22	28	18	37	200	2.47	2.55	2.70	3.46	3

Correlations between tests for composite samples 1,2,3,5 and 7

	AIV	AIVR	ACV	ACVR	10% fines
AIV	1	-0.92	0.95	-0.70	-0.94
AIVR		1	-0.98	0.57	0.91
ACV			1	-0.58	-0.95
ACVR				1	0.73
10% fines					1

the mechanical and physical tests. Composite samples 4 and 6 (Group 2) are very similar with respect to all properties with the exception of the 10 per cent fines values. Aggregate from these two samples gave the best strength characteristics of any tested from the survey area. Low AIV and ACV results (averages of 15 and 12 respectively) and high AIVR and ACVR, (averages of 44 and 46 respectively) indicate that the aggregate, in comparison with the other groups, is relatively resistant to breakdown both for residues finer than 2.36mm and those between 2.36mm and 10mm. Additional evidence of the strength of these samples is indicated by the high 10 per cent fines values, which average 300kN and are at least 100kN greater than the values obtained from other groups. The aggregates in these samples also have higher relative densities and much lower water absorption values than other composite samples.

Rather poorer test results were obtained for composite samples 1, 2, 3, 5 and 7 (Group 1), for which results were tightly clustered. The correlations between the various mechanical tests support the linear relationships between AIV, ACV, AIVR and ACVR reported by Dhir and others (1971). Correlation coefficients between AIV, AIVR, ACV and 10 per cent fines all exceed ± 0.90 (Table 6).

The test results for composite sample 8 (Group 3) lie between those for Group 1 and Group 2 composite samples with regard to all tests except AIVR and ACVR, which are rather lower and indicate that material between 2.36 and 10mm has a reduced resistance to breakdown compared to that in the other groups.

Edwards (1970) indicated that there is a broad relationship between water absorption and drying shrinkage of aggregate in concrete. Using his graph (1970, figure 1) a very broad estimate of the drying shrinkage properties of aggregate in this study can be obtained. The lowest water absorption values are for composite samples 4 and

6 (Group 2), both equal to 2.2 per cent. This gives an inferred drying shrinkage of about 0.07 per cent. Water absorption values for Group 1 composite samples range from 3.46 per cent (sample 8) to 4.1 per cent (sample 3). Extrapolation of the regression line presented by Edwards (1970) gives inferred drying shrinkage values between about 0.10 and 0.11 per cent for these samples. Gravels yielding concrete drying shrinkage values greater than 0.085 per cent lie in the category defined by the Building Research Station Digest (1968) that requires the greatest care to be exercised when they are used in concrete manufacture. It must be emphasised that inferred drying shrinkage values should be interpreted cautiously. The figures given here are for guidance alone, and tests in accordance with standard procedures would have to be carried out to determine accurate drying shrinkage values for aggregate from the survey area.

Relationship between mechanical properties and gravel composition The pebble count and mechanical test data were investigated in an attempt to discover whether there is a relationship between gravel composition and the strength of the aggregate.

The various lithologies were grouped according to whether they were considered to be durable or deleterious within the context of the mechanical tests. Merritt, Laxton, Smellie and Thomas (1983) have shown that greywacke, grits, chert, quartzite and vein-quartz can be considered as durable lithologies and these have been grouped as such. Sandstone and mudstone lithologies, on the other hand, break down relatively easily under test and are considered deleterious. Since these sedimentary lithologies constitute, in total, more than 60 per cent of the gravels examined, they should broadly determine how the aggregate behaves under test.

The mechanical behaviour of igneous rocks is partly a function of their degree of weathering.

Table 5 Data used for calculating the correlation coefficients between the lithology ratio and the mechanical test data

a) Means for the grouped lithology ratio (total of greywacke, grit, chert, quartzite, vein-quartz)/(total of sandstone, argillaceous rocks) and for the grouped mechanical test data

Group	Mean lithology ratio	Mean AIV	Mean AIVR	Mean ACV	Mean ACVR	Mean 10% fines	Composite samples
1	1.66	23.8	36.8	19	33.8	184	1,2,3,5,7
2	8.89	14.5	44	12	46	300	4,6
3	4.62	22	28	18	37	200	8

b) Individual lithology ratios and mechanical test data for composite samples in Group 1 above

Composite sample	Lithology ratio	AIV	AIVR	ACV	ACVR	10% fines
1	0.77	26	34	20	43	170
2	1.98	22	37	18	43	190
3	2.62	21	41	- No test	-	200
5	1.42	27	34	20	40	160
7	2.34	23	38	18	43	200

This is especially true of basalt, andesite and rocks of similar composition. Because the extent to which they are weathered is difficult to assess and quantify in any way, and because they constitute a much smaller percentage of the gravel composition compared with the sedimentary rocks, they have not been included in the following discussion.

In order to determine the degree of correlation between the gravel composition and the mechanical tests, the ratio of the abundance of greywacke, grit, chert, quartzite and vein-quartz to that of sandstone and mudstone was determined for each composite sample. These ratios were grouped on the same basis as the composite test samples shown in Table 2. The means for these ratios and for the mechanical test data were then determined (Table 5a) and the sample correlation coefficients between the mean ratios and the means of the test data were calculated. The results are shown in Table 6.

The correlation between the lithology and the mechanical test data was also determined for the Group 1 composite samples. The results are shown in Table 5b. Generally there is a close correlation between gravel composition and the mechanical test results, although the correlations between composition and AIVR in Table 5a and ACVR in Table 5b are exceptions. This correlation between gravel composition and mechanical and physical tests indicates that the relative proportions of the two groupings of sedimentary lithologies, listed above, exercise control over the mechanical behaviour of the aggregate.

THE MAPS

The sand and gravel resource maps are folded into the pocket at the end of this report. The base is the Ordnance Survey 1:25000 Outline Edition, which, together with the contours, is printed in grey: the geological lines and symbols are in black. Mineral resource information, including areas of potentially workable sand and gravel,

resource notes and block boundaries, is presented in shades of red.

Geological data The geological boundary lines are taken from geological maps surveyed at the scale of 1:10000 or 1:10560; these offer the best interpretation of the available data but, due to the highly variable nature of the deposits, the accuracy of the map will be improved as new evidence from boreholes and excavations becomes available.

Borehole data, which include the stratigraphical relations and mean particle-size analysis of the sand and gravel samples collected during the assessment, are also shown on the maps.

Mineral resource information The maps are divided into resource blocks (see Appendix A) within which the extent of mineral-bearing ground is shown in red. The dark shade denotes where mineral is exposed, that is, the overburden averages less than 1.0m in thickness: a lighter tone is used to identify where it is present in relatively continuous spreads beneath overburden averaging more than 1.0m in thickness. Within these areas, however, there may be small patches where sand and gravel is absent or not potentially workable, as for example, around borehole 35 NW 290.

Areas where sand and gravel is deemed to be not potentially workable, where superficial deposits do not contain mineral, or where bedrock crops out are shown uncoloured. Sand and gravel within built-up areas and patches too small or insufficiently documented to be assessed, but which may nevertheless be potentially workable, are indicated by red stipple.

For the most part the distribution of resource categories is based on mapped geological boundaries. Where transitions between categories cannot be related to the geological map, inferred boundaries have been inserted. Such boundaries, drawn primarily for the purpose of volume estimation, are shown by a distinctive zigzag symbol, which is intended to convey an approximate

Table 6 The correlation between gravel composition and the mechanical test data

a) Correlation coefficient between the means for each group of the lithology ratio (total of greywacke, grit, chert, quartzite, vein-quartz)/(total of sandstone, argillaceous rocks) and the mechanical test data

	AIV	AIVR	ACV	ACVR	10% fines
Lithology ratio (defined above)	-0.97	0.54	-0.96	0.99	0.96

b) Correlation between the individual lithology ratios and mechanical test results for Groups 1,2,3,5 and 7

	AIV	AIVR	ACV	ACVR	10% fines
Lithology ratio (defined above)	-0.85	0.92	-1.00	0.20	0.86

Correlation coefficients

A line of best fit can be determined for the relationship between any variables from a set of data. The degree of correlation of individual data points with this line, which may be either direct or inverse, can be expressed in numerical terms by calculating the sample correlation coefficient, r. This varies from +1, through 0, to -1; +1 and -1 indicate perfect positive and negative correlation, whereas 0 indicates no correlation at all. In order to discover whether pairs of variables from the mechanical and physical test results can be correlated in any way, correlation coefficients were calculated from test data for composite samples 1, 2, 3, 5 and 7. The results are shown in Table 6.

Composite samples 4, 6 and 8 were not included in these calculations because they are considered to belong to different populations, based on the test data and the pebble counts.

r is calculated from the formula:

$$r = \frac{\Sigma[(x_i - \bar{x})(y_i - \bar{y})]}{\sqrt{[(\Sigma(x_i - \bar{x})^2)(\Sigma(y_i - \bar{y})^2)]}}$$

where x_i, y_i are values of variables x and y at data point i ($0 < i \leq n$, where n = number of observations)

\bar{x}, \bar{y} are mean values of x and y

that is $\Sigma(\frac{x_i}{n})$ and $\Sigma(\frac{y_i}{n})$

location within a likely zone of occurrence rather than to represent the breadth of the zone; its width is dictated by cartographic considerations. For the purpose of measuring areas the centre-line of the symbol is used.

THE ASSESSMENT

The resource sheet area is divided into seven blocks for assessment. The positioning of the block boundaries is a compromise to meet the aims of the survey, on the one hand to provide sufficient sample points on which to base an assessment and on the other to group together deposits of broadly similar origin, thickness grade and composition.

The principal resources of sand and gravel occur as glacial meltwater deposits which embrace fluvioglacial sand and gravel and glacial sand and gravel, together with glaciolacustrine deposits. The last-named, commonly occurring in association with fluvioglacial sand and gravel, may contain

potentially workable material, but the deposits have not been recognised at the surface and have been identified only in boreholes; hence their distribution is poorly known. Additionally, the deposits generally comprise very fine sand and silt which Merritt, Laxton, Smellie and Thomas (1983) consider to have very few if any potentially commercial end-uses at present. Consequently the glaciolacustrine deposits have not been assessed. Till may be potentially workable across much of the area, as judged by the arbitrary criteria adopted for the survey, but, because the lithology is variable and the distribution of that part which is regarded as mineral is not sufficiently well known, the resource is normally excluded from the assessment. For similar reasons the alluvium is not assessed except in the valley of the Heriot Water, around Easter Howgate [242 641] and along the northern flanks of the Moorfoot Hills, where several alluvial fans have been included.

Table 7 The sand and gravel resources: summary of statistical assessments

Resource block and mineral-bearing deposits	Area		Mean thickness		Volume of sand and gravel			Yield of sand and gravel	Mean grading percentage		
	Block	Mineral	Over-burden	Mineral	Limits at the 95% probability level ±%	±m ³ x10 ⁶	m ³ per hectare	Fines	Sand	Gravel	
	km ²	km ²	m	m				- $\frac{1}{2}$ mm	-4 mm	+4 mm	
A Fluvio-glacial sand and gravel	10.6	4.8	0.3	2.7	13	26	3	27000	12	65	23
B Fluvio-glacial and glacial sand and gravel	13.2	8.5	2.0	8.2	69	66	46	82000	10	73	17
C Fluvio-glacial and glacial sand and gravel	22.4	6.5	0.7	8.4	54	48	26	84000	9	63	28
D Glacial sand and gravel	44.3	10.1	0.5	4.4	45	33	15	44000	11	45	44
E Fluvio-glacial and glacial sand and gravel	28.6	9.1	0.7	5.2	47	61	29	52000	13	52	35
F Fluvio-glacial and glacial sand and gravel	35.8	9.8	1.1	6.4	63	43	27	64000	12	61	27
Totals	154.9	48.8	-	-	291	-	-	-	-	-	-

The statistical procedure adopted for the volumetric assessment of the mineral resources is outlined in Appendix B. Statistical assessments are offered for blocks A to F, but the potentially workable deposits of block G are too patchy and diverse to assess in such a manner. Consequently, inferred assessments are offered for the lithologically similar deposits in each of the sub-blocks (except sub-block G₂) based upon sample point data and consideration of the geology and three-dimensional shape. For example, eskers have been assumed to approximate to the form of triangular prisms, the volumes of which have been calculated by simple arithmetic. Likewise mounds were often considered as hemispheres and terrace features as trapezoid prisms. Such computed volumes must be interpreted cautiously: the procedure tends to underestimate volume because no account has been taken of material that may lie below the general ground level, unless there is evidence to the contrary.

RESULTS

The mineral resources of the resource sheet area are discussed in the block descriptions. Data used in the assessment are given in Tables 9 to 15: a summary of these data is presented in Tables 7 and 8. Some conclusions are offered, following the block descriptions, regarding the resources most likely to command attention in the future.

Accuracy of results For the six resource blocks assessed statistically, the accuracy of the results at the symmetrical 95 per cent probability level ranges from 26 to 66 per cent; that is, it is probable that on average nineteen out of every twenty sets of limits constructed in this way contain the true value for the volume of mineral. However, the real values are more likely to be nearer the median than the limits. Moreover, it is probable that in each block roughly the same percentage limits would apply for the estimate of mineral volume within a very much smaller parcel

Table 8 The sand and gravel resources: summary of inferred assessments

Sub-block	Deposit	Area of mineral km ²	Mean thickness		Inferred volume of sand and gravel m ³ x10 ⁶	Mean grading percentage		
			Over-burden m	Mineral m		Fines - $\frac{1}{16}$ mm	Sand + $\frac{1}{4}$ mm	Gravel +4 mm
G ₁	Fluvioglacial and glacial sand and gravel and alluvium in the Easter Howgate area	1.4	0.6	2.5	4	18	56	26
G ₁	Glacial sand and gravel in the Sheriffhall area	0.4	0.7	1.8	1	38	56	6
G ₂	No assessment offered							
G ₃	Glacial sand and gravel in the Whim area	0.8	0.3	6.3	5	9	42	49
G ₃	Glacial sand and gravel in the Howgate area	1.2	0.4	19.1	22	18	67	15
G ₄	Alluvium of the Heriot Water	1.4	0.3	2.2	3	6	24	70
G ₄	Concealed glacial sand and gravel in the valley of the Heriot Water	1.1	-	5.7	3*	6	25	69
Totals		5.2	-	-	38	-	-	-

* For derivation of this volume, see block description

of ground (for example, 100 hectares) containing similar sand and gravel deposits if the results from the same number of sample points (as provided by, say, ten boreholes) were used in the calculation. Thus, if closer limits are needed for the quotation of reserves of part of a block, it can be expected that more than ten sample points would be required, even if the area is quite small.

However, it must again be emphasised that the quoted volume of sand and gravel has no simple relationship with the amount that could be extracted in practice, for no allowance has been made in the calculations for any restraints (such as existing buildings and roads) on the use of land for mineral working.

NOTES ON THE RESOURCE BLOCKS

The block boundaries have been drawn arbitrarily or follow the limits of built-up areas such as Edinburgh, Dalkeith and Penicuik.

Blocks A, B, and C encompass the deposits within the basin of the River North Esk. Block A includes the fluvioglacial sand and gravel with the alluvium around Dalkeith; the mineral is generally less than 5m thick. Block B contains fluvioglacial sand and gravel, the alluvium north of the River North Esk between Melville and Auchendinny and deposits concealed under the Roslin Till. Block C takes in the fluvioglacial sand and gravel south of the River North Esk between Rosewell and Auchendinny and all mineral deposits upstream from the latter to the boundary of the resource sheet. The glacial sand and

gravel in the valley of the Eddleston Water and flanking the Moorfoot Hills, as far north as Outerston Hill [335 557], is contained in block D. The fluvioglacial deposits in the Temple and Rosebery area are included in block E. Block F takes in the fluvioglacial sand and gravel in the valley of the Tyne Water from Middleton northwards. The remainder of the resource sheet area, generally containing mineral deposits of limited areal extent and patchy distribution, is placed in block G, which is divided into four sub-blocks for description.

Block A

Deposits of sand and gravel occur on both banks of the rivers North and South Esk from the northern margin of the resource sheet near Smeaton Bridge [344 696], upstream to Lasswade [310 600]. Generally the resource is exposed at the surface, that is, overburden averages less than 1m. The urban area of Dalkeith and Newbattle, which is largely underlain by sand and gravel, has not been assessed.

The resource comprises fluvioglacial sand and gravel, glaciolacustrine deposits, raised beach deposits and alluvium of various ages. Fluvioglacial sand and gravel constitutes the principal resource, accounts for 4.7km² of the surface outcrop or 44 per cent of the block area and generally occurs as dissected terraces roughly parallel to the river courses and up to 800m wide. The deposits underlying Broomieknowe Golf Course [311 662] and on ground over 90m above OD exhibit a less regular topography than those at lower levels, which they presumably pre-date.

Table 9 Block A: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $\frac{1}{4}$ mm	Fine sand $\frac{1}{4}$ mm	Medium sand $\frac{1}{2}$ mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
FLUVIOGLACIAL SAND AND GRAVEL											
36 NW 337	4.2	0.3		12	5	26	2	3	1	0	CS
36 NW 339	2.0	0.4		19	34	20	7	10	10	0	CPS
36 NW 340	2.0	1.0		9	58	31	1	1	0	0	S
36 NW 341	2.1	0.2		21	16	20	10	21	12	0	VCSCG
36 NW 342	3.2	0.2		10	13	26	12	18	19	2	SG
36 NW 344	2.8	0.1		5	14	23	11	20	23	4	SG
36 NW 345	2.1	0.2		18	11	26	10	18	15	2	CSG
36 NW 348	3.3	0.3		6	20	53	7	10	4	0	CPS
Mean	2.7	0.3		12	29	29	7	12	10	1	CPS
GLACIOLACUSTRINE DEPOSITS											
36 NW 339	4.0	2.4		28	66	6	**	0	0	0	VCS
ALLUVIUM											
36 NW 343	1.9	1.2		12	21	18	7	8	17	17	CSG

Statistical assessment of fluvioglacial sand and gravel

Area of exposed mineral	4.7km ²
Area of continuous or almost continuous spreads of mineral beneath overburden	0.1km ²
Total area of mineral	4.8km ²
Area of worked ground	<0.1km ²
Mean thickness of overburden	0.3m
Mean thickness of mineral	2.7m
Estimated volume of mineral	13 million m ³ ±26% or 3 million m ³
Estimated yield of sand and gravel per hectare	27 thousand m ³ ±26% or 7 million m ³

Potentially workable glaciolacustrine deposits were proved at depth beneath fluvioglacial sand and gravel in borehole 36 NW 339 at Melville Nurseries [306 671], but have not been recognised anywhere at the surface and are shown on the resource map only in the graphic log.

Fluvioglacial deposits have been reworked locally at various times and incorporated into terraces of late-Glacial alluvium, high raised beach deposits and alluvium of the present-day rivers. Boreholes show that the alluvium and raised beach deposits contain mineral only locally; consequently these deposits have not been assessed. The late-Glacial alluvium is considered to be barren.

Based on the eight IMAU boreholes, the mean thickness of potentially workable fluvioglacial sand and gravel is 2.7m and the mean thickness of overburden is 0.3m (Table 9). From the drilling results it is evident that in block A these deposits constitute a widespread resource of fairly even thickness. The mean grading is fines 12 per cent, sand 65 per cent and gravel 23 per cent (Table 9 and Figure 10). The grading displays no discernable regional variation.

The fluvioglacial sand and gravel proved in boreholes invariably overlay silt and clay classified as glaciolacustrine deposits, but only in borehole 36 NW 339 did they prove potentially workable.

Of the three IMAU boreholes sited on alluvial deposits, only borehole 36 NW 343, on the

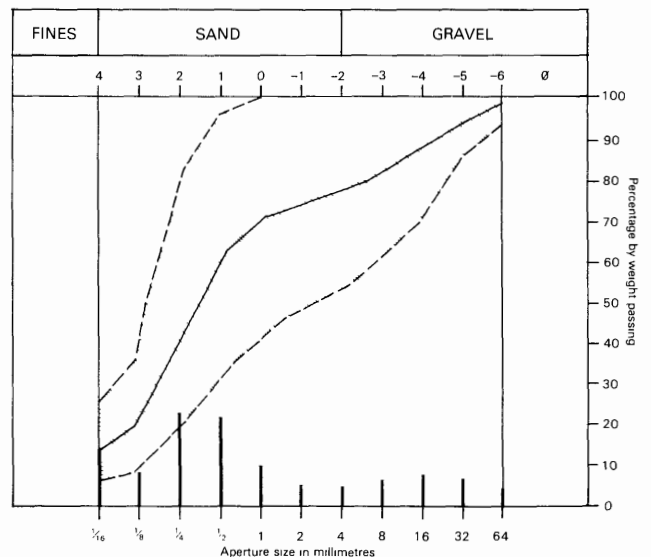


Figure 10 Grading characteristics of resources in the fluvioglacial sand and gravel of block A; for explanation see Figure 4

floodplain of the River North Esk, proved mineral. The others, 36 NW 346 and 36 NW 347, were sited on a high-level, late-Glacial alluvial terrace, where the sand and gravel is judged to be

Table 10 Block B: Data from sample points and the assessment of resources

Sample point Borehole, pit or section	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
	Total mineral m	Depth of burial m	Inter- vening waste m	Fines $\frac{1}{2}$ mm	Fine sand $\frac{1}{4}$ - $\frac{1}{2}$ mm	Medium sand $\frac{1}{2}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
FLUVIOGLACIAL AND GLACIAL SAND AND GRAVEL											
26 NE 252	5.9	0.3	0.8	14	15	15	12	18	24	2	CG
26 NE 255	23.3+	2.7		12	33	24	9	11	11	**	CPS
26 NE 256	1.4	1.8		10	19	57	8	4	2	0	PS
26 NE 257	3.2	5.0	1.2	22	32	19	6	7	11	3	VCPS
26 NE 259	1.4	1.8		19	12	35	18	11	5	0	CPS
26 NE 261	1.3	0.4		13	32	22	11	17	5	0	CSG
26 NE 263	12.0+	0.3		6	45	37	3	4	5	0	PS
26 SE 161	11.0	2.0		8	46	41	3	2	**	0	S
26 SE 163	6.0	5.8		10	60	29	1	**	**	0	CS
26 SE 164	4.6	2.0	8.4*	20	34	20	7	9	10	0	VCPS
26 SE 165	20.2	0.4	0.4	7	35	33	6	9	9	1	PS
Mean	8.2	2.0		10	37	30	6	8	8	1	CPS
GLACIOLACUSTRINE DEPOSITS											
26 NE 261	13.6	4.7		18	74	8	**	**	0	0	CS
26 SE 161	7.5	13.0	0.5	22	72	6	**	0	0	0	VCS
26 SE 164	12.3	9.5		17	68	15	**	**	0	0	CS
26 SE 165	4.3+	21.0		29	65	6	**	**	**	0	VCS
Mean	9.4	12.1		20	69	10	1	**	**	0	VCS
ALLUVIUM											
26 NE 258	1.1	1.1		16	29	16	7	14	18	0	CSG
26 NE 262	1.3+	0.8		1	7	14	13	18	23	24	G
Mean	1.2	1.0		8	17	15	10	16	21	13	SG

* Includes 2.3m of potentially workable glaciolacustrine deposits

Statistical assessment of fluvioglacial and glacial sand and gravel

Area of exposed mineral	3.4km ²
Area of continuous or almost continuous spreads of mineral beneath overburden	5.1km ²
Total area of mineral	8.5km ²
Area of worked ground	1.1km ²
Mean thickness of overburden	2.0m
Mean thickness of mineral	8.2m
Estimated volume of mineral	69 million m ³ ±66% or 46 million m ³
Estimated yield of sand and gravel per hectare	82 thousand m ³ ±66% or 54 thousand m ³

not potentially workable. Even with ancillary borehole information there are insufficient data to provide a confident estimate of mean thickness or grading for the alluvium, but it is unlikely to exceed 2m in thickness.

The permanent water table was proved in boreholes 36 NW 337 and 339, at 3.3m and 4.6m respectively beneath ground level. In boreholes 36 NW 340, 341, 342 and 345 perched water tables were met. Elsewhere, water was not struck or was encountered only in minor amounts.

Sand and gravel was formerly worked near Burndale [308 678], now restored, and in small pits near Broomhill at [309 664] and near Lugton Bogs at [318 675].

There is sufficient information to provide a statistical assessment only for the fluvioglacial sand and gravel. Details are given in Table 9.

Block B

The block includes the sand and gravel deposits north of the River North Esk between Auchendinny [255 621] and Middlemills [305 664]. Around Roslin and Loanhead the deposits are mainly buried beneath till. An inferred boundary limits the extent of buried sand and gravel deposits as determined from IMAU and ancillary borehole information. The area is fairly flat-lying but gently inclined south-eastwards towards the deeply incised valley of the River North Esk.

Except where exposed, the bedrock throughout the block is generally thought to be mantled by a basal (lodgement) till composed of stiff stony clay, generally grey, greyish brown or reddish brown in colour. All IMAU boreholes proving rock, except 26 NE 252, penetrated till, which varied in thickness from 0.3m in borehole 26 NE 259 to 9.2m in borehole 26 SE 163. Glacial meltwater deposits overlie the till and contain the bulk of the sand and gravel resources. The meltwater deposits are

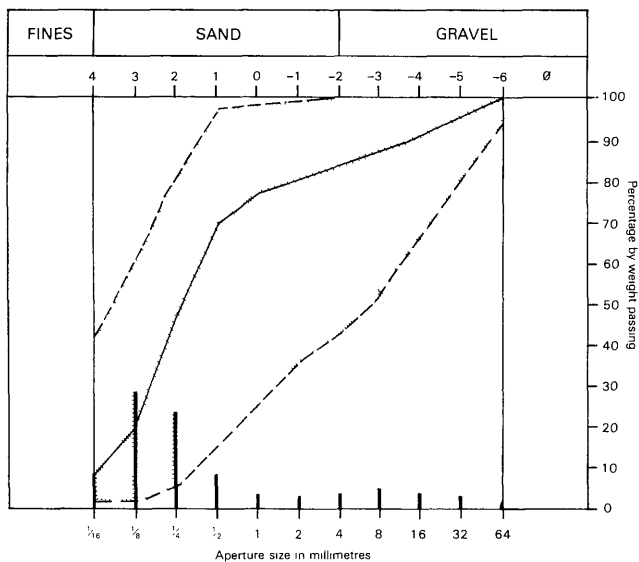


Figure 11 Grading characteristics of resources in the fluvioglacial and glacial sand and gravel of block B; for explanation see Figure 4

mainly of fluvioglacial sand and gravel, commonly with underlying glaciolacustrine sediments, but around Old Pentland [264 661] and Straiton [273 666] they comprise glacial sand and gravel. The glacial meltwater deposits in turn are extensively buried by a surface deposit of stiff, sandy, stony clay, reddish brown in colour, varying in thickness from 0.9m in borehole 26 NE 256 to 3.6m in borehole 26 SE 163, and sometimes termed the "Roslin Till" (Kirby, 1968). Elsewhere, glacial sand and gravel usually forms mounds and ridges, and fluvioglacial material flattish spreads. Samples from pits 26 NE 262 and 26 NE 258 indicate that alluvium flooring the valleys of the River North Esk and May Burn respectively, is potentially workable.

The thickness and composition of the glacial meltwater deposits are related to their mode of deposition. The fluvioglacial and glaciolacustrine sediments were deposited respectively at the margins and in the deeper parts of an ice-dammed lake which is believed to have occupied part of the Midlothian Basin. Palaeocurrent directions and bedforms observed in working and abandoned pits indicate that the fluvioglacial sediments were deposited in a deltaic environment from meltwaters flowing in a north-easterly direction. At the same time, finer grained glaciolacustrine sediment would have settled on the lake bed, the grain-size gradually decreasing away from the front of the delta. The prograding nature of the system caused the glaciolacustrine deposits to pass up imperceptibly into the coarser grained fluvioglacial sediments. Much of the fluvioglacial material is composed of sand typical of delta- or fan-front deposits, though the upper part of the sequence proved gravelly at most IMAU sample points and is considered to be delta-top and channel-fill deposits. Because of the variation in depositional environments across the block, as illustrated by the differing sequences of sediments penetrated by IMAU boreholes, it is not possible to make reliable statements about the nature of the glacial meltwater deposits between boreholes.

The fluvioglacial deposits constitute the bulk of the resource. They are generally thickly developed and display a coarsening-upwards

sequence. Borehole evidence suggests that the thickest deposits of sand and gravel are mainly located in a strip up to 1.5km wide along the south-eastern margin of the block. Outside this area, no IMAU sample points proved glaciolacustrine deposits and only one sample point, 26 NE 255, penetrated meltwater deposits to a depth in excess of 25.0m. In the south-west of the block, near Oatslie [262 624], borehole 26 SE 161 proved 11.0m of fluvioglacial sediments beneath till. The uppermost 5.0m of mineral graded as pebbly sand and overlay 6.0m of 'clayey' sand which fined with depth into glaciolacustrine deposits, only the uppermost 8.0m of which graded as mineral. Although the base of the glacial meltwater deposits was not proved by the borehole, it is unlikely that sand and gravel are present beneath the laminated glaciolacustrine silts found at the base of the hole. Nearby a similar sequence of fluvioglacial sediments was worked in the Oatslie sand pits where up to 9.0m of sand, gravelly in the uppermost 3.0m, were taken from beneath a cover of till, 0.9 to 3.0m thick. Potentially workable glaciolacustrine deposits are almost certain to underlie the floors of the pits but have never been worked. The full thickness of the glacial meltwater deposits was not proved to the east and north-east of Roslin where boreholes 26 SE 164 and 165 were terminated at depths of 25.0m and 25.3m respectively. At borehole 26 SE 165, near Rosslyn Chapel [275 631], a thin flow till at 5.8m separated gravelly fluvioglacial sediments from fine to medium sand with rare pebbles which passed down at 21.0m into glaciolacustrine deposits of sand with silt and clay seams. In borehole 26 SE 164 the meltwater deposits were overlain by 1.8m of till: an upper deposit of fluvioglacial sand and gravel 1.4m thick was separated from a lower deposit 3.2m thick by 8.4m of glaciolacustrine laminated silt and sand of which the uppermost 6.1m graded as non-mineral: 10.0m of potentially workable silty, fine sand at the base of the hole were not bottomed.

To the east of Loanhead the glacial meltwater deposits are also thickly developed. In borehole 26 NE 261, just south of Haveral Wood Pit, gravelly fluvioglacial material 1.3m thick was underlain by 3.0m of flow till. Beneath the flow till and overlying a lodgement till, 14.8m of glaciolacustrine sediment was proved which fined with depth becoming non-mineral in the lowermost 1.2m. The fluvioglacial sediments exposed in Haveral Wood Pit are predominantly composed of sand, typical of delta- or fan-front deposits, which become finer grained southwards towards the borehole. To the east of this locality exposed fluvioglacial sand and gravel is currently being extracted at Melville Pit. In the working face (section 26 NE 263) the upper, delta-top deposit graded as gravel, ranged in thickness from 1.5 to 2.5m and had an irregular erosive contact with the underlying delta-front sands of which a maximum of 10.0m was visible in October 1982. Hearsay evidence suggests that the workings have exploited almost the full thickness of the deposits. The sand and gravel is believed to thin northwards from the pit, the direction in which the workings are progressing. Near Parkburn [293 671] borehole 26 NE 259 penetrated only 1.4m of mineral, grading as 'clayey' pebbly sand, overlying a basal till and buried beneath a flow till.

The glacial meltwater deposits are thought to thin northwards and north-westwards from Roslin as indicated by the presence of bedrock cropping out in Bilston Glen and around New Pentland [268 657]. Borehole 26 SE 163 at Langhill Farm [268 642]

penetrated 3.6m of flow till on 8.0m of fluvioglacial sediment (the uppermost 2.0m graded as non-mineral), overlying a basal till. The potentially workable material graded as '*clayey sand*', the gravelly delta-top facies deposits recorded in all other IMAU boreholes in the block being absent. A similar deposit was worked at Bilston sand pit where up to 4.0m of sand and gravel were extracted from beneath up to 2.1m of till. North of Bilston [261 647], sand and gravel is known to have been worked at three localities. At Nivens Knowe an infilled pit showed 3.0m of sand and gravel beneath 1.2m of till; and up to 6.0m of gravel and sand were formerly exposed beneath 0.9m of till in the pit near Pentland Mains [259 655]. In the pit between Old Pentland and New Pentland, currently being infilled, up to 6.0m of finely bedded sand and gravel were visible beneath 0.6 to 1.2m of till. The full thickness of the glacial meltwater deposits was not revealed at any of these localities. Borehole 26 NE 256, drilled to the east of the last-mentioned pit, suggested that the sediments hereabouts thin eastwards: 0.9m of flow till overlay 1.4m of '*clayey pebbly sand*' on 0.7m of laminated sandy silt on basal till. West of the pit at Old Pentland, however, fluvioglacial sand and gravel buried beneath 2.0m of flow till was not bottomed at a depth of 26.0m, though the extent of deposits of such thickness is thought to be limited. The sediments are unusual in that to a depth of 17.3m they were predominantly composed of gravel, unlike much of the mineral in the block. A small sand pit in the exposed fluvioglacial sediments to the west of Straiton shows 7.0m of fine to medium sand with scattered pebbles. A borehole about 100m south of the pit proved 9.5m of sand and gravel overlying a basal till.

Glacial sand and gravel deposits form mounds and ridges and are also believed to occur beneath flow till to the north and north-west of Old Pentland. The sediments are thought to be generally composed of gravel as noted from numerous small exposures examined during the field survey. Borehole 26 NE 252, near Lothianburn [250 670], demonstrated a poorly sorted '*clayey gravel*' deposit 4.0m thick, separated by a thin flow till from 1.9m of well sorted '*clayey sandy gravel*' overlying bedrock. Near the site of Broomhill House 11.0m of sand and gravel beneath peat were recorded in a borehole [2651 6896]. To the north-west of Straiton, borehole 26 NE 257 proved 7.8m of glacial sand and gravel, only 3.2m of which graded as mineral, buried beneath head, and overlying basal till.

The potentially workable glacial meltwater deposits mainly lie above the water table; those below are mainly of glaciolacustrine origin. Of the eleven sample points in the block proving meltwater deposits five did not encounter groundwater in the mineral and 67.5 per cent of the sand and gravel sampled lay above the water table.

The valleys, commonly floored by bedrock, contain thin ribbons of alluvium which are not thought to constitute a significant resource. Data on the deposits have been excluded from the block calculations. Pit 26 NE 258 at Ashgrove [279 664] demonstrated the alluvium of the May Burn to comprise 1.1m of poorly sorted, '*clayey sandy gravel*'. In the valley of the River North Esk, alluvium forms extensive terraces around Polton [292 648], where pit 26 NE 262 did not bottom a gravelly deposit at a depth of 2.1m.

Sand and gravel underlies the villages of Loanhead, Roslin and Bilston and spent oil shale tips near Dryden Mains [276 640] and at Pentland.

A significant amount of material has been extracted from pits and working continues at two localities (Table 16). Nonetheless, the glacial meltwater deposits in the block offer significant potential for exploitation by dry working methods, especially for sand, even though they are mainly buried beneath flow till. Further information on the resource is presented in Table 10 and Figure 11.

Block C

From the margin of the resource sheet near Brunston [201 583] to Auchendinny the block takes in sand and gravel deposits on both sides of the River North Esk, although most lie to the north-west. Downstream of Auchendinny to Bonnyrigg and Lasswade, resources on the south-east bank of the River North Esk and east of Rosewell are included.

The principal resource is contained in the glacial meltwater deposits, which form discontinuous outcrops. West of Penicuik the deposits are chiefly classified as glacial sand and gravel and occur as a series of mounds, commonly elongate, arcuate and forming marked features, for example Long Knowe [205 599], which stands over 20m above the surrounding ground surface. The form of the deposits reflects the mode of deposition. Elsewhere, the deposits are classified as fluvioglacial sand and gravel: these are post-depositionally dissected flattish spreads. Glaciolacustrine deposits were identified in several boreholes, mainly on the basis of grain-size analysis, but these deposits have not been recognised at the surface.

Seven boreholes proved the full drift succession to rockhead, three were still in superficial deposits (till) at 25m, the maximum depth of drilling, and the remainder were terminated prematurely for technical reasons. The material underlying the lowest mineral deposits in boreholes comprised either till or glaciolacustrine deposits.

Potentially workable sand and gravel is generally found within 1m of the surface, the main exception being in the area between Coates and Cuiken [232 611], where boreholes 26 SW 83 and 86 proved 2.2m and 4.0m, of overburden respectively.

Based on one ancillary record and fifteen IMAU sample points, the mean thicknesses of mineral and overburden in the fluvioglacial and glacial sand and gravel are 8.4m and 0.7m, respectively (Table 11). The greatest mineral thicknesses proved were in boreholes 25 NW 77 and 26 SW 84 on the Penicuik Estate and borehole 36 SW 250 south-east of Rosewell. Borehole 26 SE 162 proved 15.4m of gravel before being terminated by an obstruction. The thickness of mineral proved in boreholes (Table 11) displays a marked variation. Mounds and ridges of glacial sand and gravel may contain considerable thicknesses; for example, borehole 26 SW 84, sited on the crest of an arcuate ridge, proved a resource 16.9m thick. By contrast, boreholes 25 NW 75 and 76, sited on flattish ground, proved 2.7m and 2.5m of potentially workable glacial sand and gravel, respectively. In the fluvioglacial sand and gravel, boreholes indicate that the deposit thins down-valley towards the north-east, although there are exceptions, for example, borehole 26 SE 159, which proved 6.3m of *sandy gravel*, probably close to the margin of the deposit. Borehole 36 SW 250 proved 22.6m of '*clayey pebbly sand*' in contrast to borehole 26 SE 170 nearby, which penetrated 3.8m of *sandy gravel*, suggesting that the thicker deposit fills a depression.

Two IMAU boreholes identified mineral deposits beneath overburden exceeding 1m in

Table 11 Block C: Data from sample points and the assessment of resources

Sample point Borehole or pit	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
	Total mineral m	Depth of burial m	Inter- vening waste m	Fines $\frac{1}{16}$ mm	Fine sand $\frac{1}{8}$ mm	Medium sand $\frac{1}{4}$ mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
FLUVIOGLACIAL AND GLACIAL SAND AND GRAVEL											
25 NW 74	3.1	0.8		18	37	20	4	10	11	0	CSG
25 NW 75	2.7	0.2		9	9	16	12	23	26	5	G
25 NW 76	2.5	0.2	5.5*	6	9	34	12	26	13	0	SG
25 NW 77	17.0	0.4	6.4§	6	39	31	9	9	6	0	PS
26 SW 83	4.6	2.2	2.4	21	64	6	2	3	3	1	VCPS
26 SW 84	16.9	0.3		14	34	28	10	9	5	**	CPS
26 SW 86	1.6	4.0		7	15	15	6	11	21	25	G
26 SW 94	6.8	0.2		9	47	33	3	4	4	0	PS
26 SE 159	6.3	0.3		8	8	18	21	24	18	3	SG
26 SE 162	15.4+	0.3		7	9	20	15	20	26	3	G
26 SE 168	5.4	0.4		6	8	17	11	29	25	4	G
26 SE 169	2.1	0.9		8	8	28	16	20	20	0	SG
26 SE 170	3.8	0.3		6	15	34	10	17	18	0	SG
36 SW 250	22.6	0.2	0.8	10	45	40	2	2	1	0	CS
SE 23 1	14.9+	0.3		1	4	18	18	23	23	13ø	G
Mean	8.4	0.7	0.5	9	27	26	10	13	12	3	SG
GLACIOLACUSTRINE DEPOSITS											
25 NW 75	1.0	4.6		26	61	12	0	1	0	0	VCS
25 NW 76	4.0	1.0	1.5	24	65	10	**	1	0	0	VCS
25 NW 77	5.2	12.8	1.2	26	67	7	**	**	0	0	VCS
26 SW 94	5.5	7.0		29	67	4	**	**	0	0	VCS
Mean	3.9	6.4		27	66	7	**	**	0	0	VCS
ALLUVIUM											
26 SW 82	1.8	0.2		4	8	11	14	20	23	20	G

* Includes 4.0m of potentially workable glaciolacustrine deposits

§ Includes 5.2m of potentially workable glaciolacustrine deposits

ø Grading data refers to uppermost 7.9m only

Statistical assessment of fluvioglacial and glacial sand and gravel

Area of exposed mineral	6.4km ²
Area of continuous or almost continuous spreads of mineral beneath overburden	0.1km ²
Total area of mineral	6.5km ²
Area of worked ground	<0.1km ²
Mean thickness of overburden	0.7m
Mean thickness of mineral	8.4m
Estimated volume of mineral	54 million m ³ 48% or 26 million m ³
Estimated yield of sand and gravel per hectare	84 thousand m ³ 48% or 40 thousand m ³

thickness. In borehole 26 SW 83, 'very clayey' sand underlay 2.2m of soil and flow till. The outcrop of the till is probably of limited extent, as shown on the resource map. Borehole 26 SW 86 at Cuiken proved 4.0m of soil and till on 1.6m of gravel. A number of other borehole records held by IGS also confirm the existence of sand and gravel underlying the Cuiken district of Penicuik, now built on; no attempt has been made to demarcate the possible extent of a concealed resource thereabouts.

The mean grading of potentially workable fluvioglacial and glacial sand and gravel is fines 9 per cent, sand 63 per cent and gravel 28 per cent (Table 11 and Figure 12).

West and north of Penicuik, four boreholes were sited on glacial sand and gravel, and boreholes 25 NW 77 and 26 SW 86 proved the same

material at depth. Boreholes 25 NW 75 and 76 penetrated thin deposits of gravel overlying glaciolacustrine deposits, some seams of which graded as mineral. Boreholes 26 SW 84 and 25 NW 74 proved 16.9m and 3.1m respectively of 'clayey' sand and gravel, the former having been sited on the crest of a ridge and the latter on a flat between mounds.

A more readily discernible pattern of deposition is recognisable in the fluvioglacial sand and gravel, which is believed to have been laid down as delta-fan deposits by meltwaters emanating from retreating or stagnant ice, and subsequently dissected by fluvial action. Boreholes show the surface deposits are without exception pebbly or gravelly, but the thicknesses are variable. Boreholes 26 SE 159, 168, 169 and 170 proved mineral deposits no thicker than 6.3m.

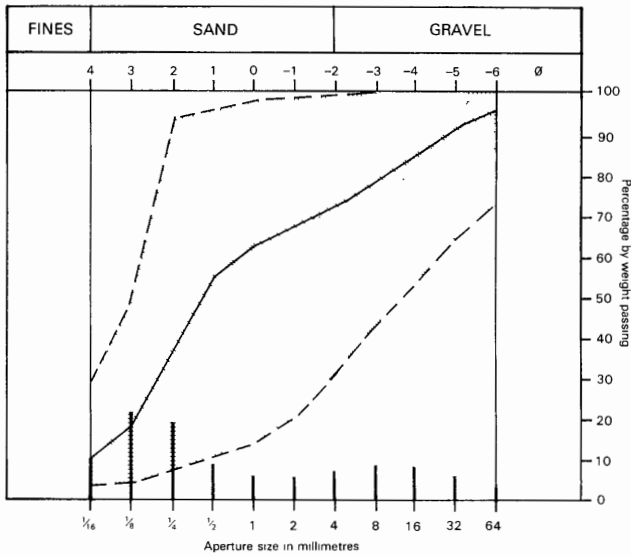


Figure 12 Grading characteristics of resources in the fluvio-glacial and glacial sand and gravel of block C; for explanation see Figure 4

In the remaining IMAU boreholes that penetrated more than 10m of fluvio-glacial sand and gravel, excepting borehole 26 SE 162 which proved gravel to the termination depth of 15.7m, it is clear that the gravelly surface deposits overlie predominantly sandy sequences, the lower parts of which are classified as glaciolacustrine deposits in boreholes 25 NW 77 and 26 NW 94. A similar succession was penetrated by borehole 26 SE 165 in block B. Potentially workable glaciolacustrine deposits were sampled from four boreholes, all in the western half of the block. The mineral deposits were commonly interbedded with non-mineral sequences of sandy and clayey silts.

Pit 26 SW 82 proved 1.8m of gravel, classified as alluvium. In common with the alluvium of the River North Esk, for which no sample points exist in block C, these deposits are not assessed. The mean thickness of mineral is likely to average 1m.

The majority of the sand and gravel in the block would be capable of dry working on the

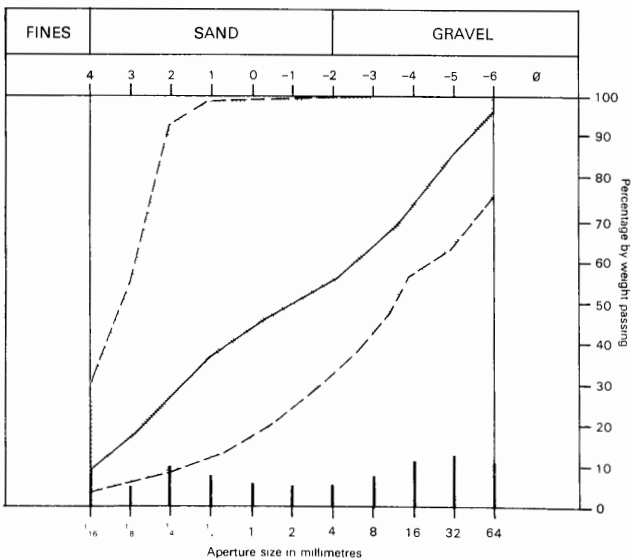


Figure 13 Grading characteristics of resources in the glacial sand and gravel of block D; for explanation see Figure 4

evidence of IMAU boreholes. Exceptions were boreholes 26 SE 159 and 168, which proved groundwater within 3m of the surface, and borehole 26 SW 86, where the buried mineral deposit acted as an artesian aquifer. Boreholes 25 NW 77, 26 SW 94 and 26 SE 162 penetrated the permanent water table near the bases of the sand and gravel deposits. The remainder were dry or struck perched water tables. Boreholes indicate that there is a general decline in water table level from west to east (for example 256.7m above OD in 26 SW 84 to 136m above OD in 26 SE 169).

There are no active sand and gravel workings in block C, although pits formerly existed at Parkneuk [296 630], in the neighbourhood of Hawthornden at [299 632] and at two sites within the built-up area of the Penicuik (Tulloch and Walton, 1958). The Ordnance Survey base map records a former working near Rosslyn Lee at [267 621].

Block D

With a total area of 44.3km², block D includes most of the glacial sand and gravel on the southern resource map, and encloses the undulating ground between Waterheads [243 509] in the west and Chester Hill in the east. Its western boundary marks the transition to mineral-bearing ground from the predominantly mineral-free area of sub-block G₃, whereas the south-eastern boundary coincides with the fault scarp of the Moorfoot Hills. To the north, the block boundary approximates to the northern limit of glacial sand and gravel at outcrop. Drainage is predominantly north-eastwards, except in the south-west where a bedrock high causes the Eddleston Water to drain southwards.

The block includes large patches of predominantly barren till, frequently overlain by spreads of peat, as around Side Moss [287 550] and Yorkston Moss [327 546]. These form extensive wild upland areas. Mineral occurs in the glacial sand and gravel and beneath alluvium. Boreholes 25 NW 20, 35 NW 298 and 35 SW 9 proved the basal parts of the glaciolacustrine deposits to be potentially workable. Additionally areas of alluvial fan and glacial sand and gravel associated with glacial drainage channels and valleys on the northern scarp of the Moorfoot Hills have been included in the assessment because they are thought to contain deposits of greywacke gravel.

The mineral-bearing ground can be conveniently divided into three areas: that in the valley of Eddleston Water, in the west; a roughly semicircular outcrop commencing in the north, near Mount Lothian, and swinging southwards and eastwards round the southern margin of Gladhouse Reservoir to end near Blackburn Strip [315 543]; and an isolated but thick patch in the extreme north-east.

The glacial sand and gravel of the Eddleston valley was investigated by three boreholes and three pits. All proved mineral which varied in thickness from 1.0m in pit 25 SW 17 to in excess of 10.0m in 25 SW 21, the latter sample point being a composite of a quarry face and a pit dug at its foot. The full mineral thickness was probably not proved in borehole 25 SW 20, which was abandoned on an obstruction. The deposits range in grading from sandy gravel to gravel, partly 'clayey' and 'very clayey' although glaciolacustrine deposits which graded as 'very clayey' sand were encountered in borehole 25 SW 20. Pit 25 SW 17 proved 1.0m of gravel in an area of poorly defined mounds of glacial sand and gravel, whereas borehole 25 SW 18, at a high elevation,

Table 12 Block D: Data from sample points and the assessment of resources

Sample point Borehole, pit or section	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
	Total mineral m	Depth of burial m	Inter- vening waste m	Fines $-\frac{1}{16}$ mm	Fine sand $+\frac{1}{16}$ $-\frac{1}{32}$ mm	Medium sand $+\frac{1}{8}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
GLACIAL SAND AND GRAVEL											
25 NE 135	1.8	0.3		19	19	11	11	21	19	0	CSG
25 NE 136	2.6	0.2		7	5	10	15	25	38	0	G
25 NE 138	5.0	0.1		6	4	13	14	26	32	5	G
25 SW 16	1.0	3.0		15	6	11	14	22	24	8	CG
25 SW 17	1.0	0.2		7	3	8	15	29	38	0	G
25 SW 18	4.4	0.3		23	19	11	12	20	15	0	VCSG
25 SW 19	1.8+	0.3		5	8	26	14	26	21	0	SG
25 SW 20	3.5+	0.3	5.0*	20	26	10	9	22	13	0	VCSG
25 SW 21	10.0+	0.3		7	19	17	10	17	26	4	G
25 SE 1	6.6	0.2		8	6	9	13	23	26	15	G
25 SE 3	5.0	1.0	0.2	8	5	11	16	32	28	0	G
25 SE 4	4.1	0.2		6	10	20	14	19	26	5	G
25 SE 5	4.8	0.2		9	6	9	13	25	28	10	G
25 SE 6	1.0	0.3		10	4	9	15	32	30	0	CG
35 NW 298	8.0	0.2		16	55	27	1	1	**	0	CS
35 SW 6	7.1	0.2		9	7	7	11	24	40	2	G
35 SW 9	7.0	0.6		12	36	32	8	8	4	0	CPS
Mean	4.4	0.5		11	18	16	11	19	21	4	CG
GLACIOLACUSTRINE DEPOSITS											
25 SW 20	4.0	1.3	1.0	30	68	1	**	**	1	0	VCS
35 NW 298	4.1	9.2		24	64	11	1	**	**	0	VCS
35 SW 9	3.1	9.5		36	48	14	2	0	0	0	VCS
Mean	3.7	6.7		29	62	8	1	**	**	0	VCS

* Includes 4.0m of potentially workable glaciolacustrine deposits

Statistical assessment of glacial sand and gravel and alluvial fan deposits

Area of exposed mineral	9.9km ²
Area of continuous or almost continuous spreads of mineral beneath overburden	0.3km ³
Total area of mineral	10.1km ²
Area of worked ground	0.4km ²
Mean thickness of overburden	0.5m
Mean thickness of mineral	4.4m
Estimated volume of mineral	45 million m ³ ±33% or 15 million m ³
Estimated yield of sand and gravel per hectare	44 thousand m ³ ±33% or 15 thousand m ³

proved 4.4m of 'very clayey' sandy gravel overlying thick till, suggesting that the deposits on the valley sides are thin and patchy and that in the central part they fill a pre-existing steep-sided valley. Extraction of sand and gravel is currently taking place at Cowieslinn and Ship Horns; sand and gravel was won from a pit at Nether Falla, which is now being infilled with domestic refuse. Overburden in this area is generally thin, borehole 25 SW 16, which proved 3.0m of fill and soliflucted deposits, being exceptional. Only one borehole, 25 SW 20, which penetrated 1.0m of silt, proved waste within the mineral-bearing sequence.

In the central part of the block, glacial sand and gravel crops out as mounds and esker-like ridges. These are frequently partially overlain by peat and thin alluvium, and are also elongated to the north-east. Drainage channels also grade in this direction indicating that the source of sediment was to the south-west. Moundy, moraine-like deposits exist, for example, around

borehole 35 SW 5, which proved 2.2m of 'clayey' sandy gravel, but because of the uncertain nature of its grading this deposit has been excluded from the assessment. Borehole 25 SE 2 proved only a thin veneer of sandy boulder clay overlying bedrock. Other sample points in the vicinity encountered chiefly gravels, which ranged in thickness from 1.0m in pit 25 SE 6 to 7.1m in borehole 35 SW 6. The cobble content ranged up to 15 per cent in borehole 25 SE 1. Borehole 35 SW 9 proved 7.0m of deposits ranging from 'clayey' sandy gravel at the top to 'very clayey' and pebbly sand below. These overlie a parting of silt and 3.1m of 'very clayey' sand both of which are classified as glaciolacustrine deposits. Mineral was proved beneath 1.0m of alluvial overburden in borehole 25 SE 3. Alluvium, generally overlying till, is thought to be not potentially workable, or, at best, to contain only thin, discontinuous patches of sand and gravel. Overburden ranges from 0.1 to 1.0m and usually comprises clay and soil.

On the available evidence, most deposits in this central area could be worked dry, with the exception of those around borehole 25 SE 3, where water was struck at 3m below the ground surface. In borehole 25 SE 5, water was struck in a gravel seam in the underlying till, so, unless such deeper deposits were also worked, water should not be a problem.

In the north-east of the block, borehole 35 NW 298 proved 8.0m of glacial sand and gravel, which graded as 'clayey' sand with rare seams of gravel. This was underlain by 1.0m of silt and 4.1m of 'very clayey' sand classified as glaciolacustrine deposits. Mineral hereabouts occurs in mounds and ridges, and field observations and ancillary borehole information suggest that it is thick and predominantly sandy. Overburden is thin and, on the evidence of 35 NW 298, the deposits could be worked dry. In this area, till underlying glaciolacustrine deposits contains seams of sand and gravel which grade as mineral but have not been included in the assessment.

Along the south-eastern block boundary, field inspection suggests that deposits mapped as glacial sand and gravel and alluvial fans along the Moorfoot Hills scarp contain sand and angular greywacke gravel. These areas have been included in the assessment although they were not investigated with boreholes or pits.

For the block as a whole, the mineral bearing area is 10.1km². The mean grading of the glacial sand and gravel is fines 11 per cent, sand 45 per cent, and gravel 44 per cent (including 4 per cent cobbles), and the mean thickness is 4.4m. Further information is given in Table 12 and Figure 13.

Block E

The block includes the patchy deposits of sand and gravel around the villages of Temple and Carrington. The area is gently undulating, rising gradually southwards towards the Moorfoot Hills, and is dissected by the deeply incised valleys of the River South Esk and its tributaries, the Redside and Castleton burns.

Bedrock is locally exposed in the valley floors and forms some hillocks, but generally it is buried by a stiff lodgement till composed of stony clay which proved difficult to drill: only four IMAU boreholes in the block bottomed the deposit. The till varies in colour from shades of brown to reddish brown, greyish brown and dark yellowish brown, locally changing from reddish brown to a greyish yellow-brown with depth. The thickness of the deposit proved in boreholes ranged from 1.4m in borehole 35 NW 296 to in excess of 11.8m in borehole 35 NW 292, but usually exceeded 5.0m. The thickest deposits of till were found to the south of Yorkston and between Carrington and Temple. At Fullarton [280 570], the uppermost 1.8m of till in borehole 25 NE 140 graded as mineral though this has not been considered in the assessment of resources. Boreholes 25 NE 139 and 35 SW 8 demonstrated that the glacial meltwater deposits overlying the basal till include a thin bed of till. Around Carrington, Temple and Yorkston a till, probably a solifluxion deposit, in places overlies potentially workable sand and gravel deposits. It varied in thickness from 0.3 to 2.3m in pit 35 NW 293 and borehole 35 NW 290 respectively, and is considered non-mineral owing to excessive fines content.

Except for the mineral till proved at one sample point, all the potentially workable material in the block is in the glacial meltwater

deposits. The resource predominantly comprises fluvioglacial sand and gravel which generally forms flattish spreads; glacial sand and gravel forms ridges and mounds. The patchy nature of the deposits suggests that they were deposited from glacial meltwaters flowing around decaying masses of ice, the direction of flow being in a north-easterly direction away from ice sheets in the Southern Uplands and Moorfoot Hills.

Around Carrington a number of isolated patches of fluvioglacial sand and gravel overlie till. At Whitehill Aisle [322 612] a borehole demonstrated silty sand with gravel to a depth of 7.8m on till. Elsewhere sand and gravel was noted in scrapes and small sections. Additionally, to the south of Carrington borehole 35 NW 289 proved 3.4m of 'clayey' gravel buried beneath 2.1m of flow till and overlying what was thought to be a basal till. Borehole records held by IGS also indicate the presence of buried sand and gravel deposits to the west and south-west of Carrington, where the thickness of mineral does not generally exceed 3.0m, but 11.3m was proved in a borehole near Redside [306 594]. Overburden is up to 7.0m thick but generally is less than 2.0m. A flow till was also proved at the surface by boreholes 35 NW 290 and 35 NW 294 near Braidwood [311 587] and at Arniston [326 595], respectively. At the former site the till overlay 0.8m of sand and gravel, but at the latter locality 5.5m of mineral, which became finer grained with depth, was encountered beneath 1.6m of till overburden. Other boreholes around Arniston penetrated gravel, which passed downwards into sand beneath a thin till overburden: a maximum thickness of 8.6m of mineral was proved. Areas of buried sand and gravel around Arniston and south of Carrington have been delineated by inferred boundaries on the resource map. Around Temple spreads of fluvioglacial sediment overlie till beneath which, according to borehole information, sand and gravel is absent. The mineral deposits hereabouts are generally thin and boreholes demonstrated till at the surface within the areas of mapped fluvioglacial deposits near Braidwood and Crow Wood [332 589]. To the west of the River South Esk the available evidence suggests that sand and gravel is thinner than to the east. Near Rosebery [305 574] borehole 35 NW 287 and pit 35 NW 288

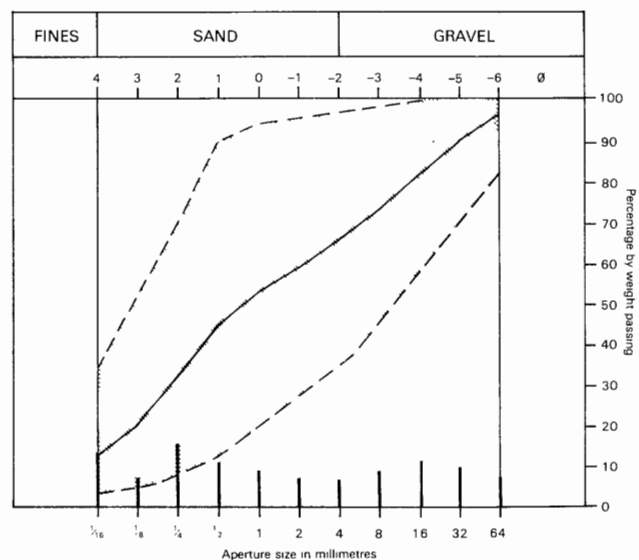


Figure 14 Grading characteristics of resources in the fluvioglacial and glacial sand and gravel of block E; for explanation see Figure 4

Table 13 Block E: Data from sample points and the assessment of resources

Sample point Borehole or pit	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
	Total mineral m	Depth of burial m	Inter- vening waste m	Fines $\frac{1}{16}$ mm	Fine sand $\frac{1}{8}$ mm	Medium sand $\frac{1}{4}$ mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
FLUVIOGLACIAL AND GLACIAL SAND AND GRAVEL											
25 NE 137	17.9	0.2		11	25	24	12	15	12	1	CSG
25 NE 139	7.9	0.2	2.9	14	30	17	11	14	11	3	VCSG
25 NE 140	6.4	0.3		18	28	14	8	18	11	3	CSG
25 NE 141	1.9	0.3		22	24	15	9	15	15	0	VCSG
35 NW 287	2.3	0.8		26	39	18	4	6	7	0	VCPS
35 NW 289	3.4	2.3		10	7	10	11	25	33	4	CG
35 NW 292	1.6	0.3		21	24	16	7	14	12	6	VCSG
35 NW 293	1.4+	0.7		16	32	20	6	11	15	0	CSG
35 NW 294	5.5	1.9		8	6	20	19	21	24	2	G
35 NW 295	1.3	0.3		4	4	13	15	23	30	11	G
35 NW 297	8.4	0.4		8	7	20	14	25	20	6	G
35 SW 8	4.3	0.2	3.4	21	25	15	8	13	14	4	VCSG
Mean	5.2	0.7		13	22	19	11	17	15	3	CSG

Statistical assessment of fluvioglacial and glacial sand and gravel

Area of exposed mineral	7.1km ²
Area of continuous or almost continuous spreads of mineral beneath overburden	2.1km ²
Total area of mineral	9.1km ²
Area of worked ground	<0.1km ²
Mean thickness of overburden	0.7m
Mean thickness of mineral	5.2m
Estimated volume of mineral	47 million m ³ ±61% or 29 million m ³
Estimated yield of sand and gravel per hectare	52 thousand m ³ ±61% or 32 thousand m ³

proved 2.3m and 0.4m respectively of sand with gravel and borehole 25 NE 141, in Steelfoot Strip, demonstrated 1.9m of 'very clayey' sandy gravel overlying till. East of the river, borehole records held by IGS indicate the sand and gravel at Temple School [317 586] to be 4.0m thick on bedrock, whereas to the east of Temple Farm [322 580] mineral was proved to depths of between 2.7 and 11.3m, overlying basal till. At Rylaw Knowe [330 586] sand is reported to have been worked, though no data are available on the thickness or grade of the deposit. In the glacial drainage channel to the north of Crow Wood a 2.4-m surface deposit of peat overlies 6.5m of sand and gravel on bedrock. North of Outerston [330 570] fluvioglacial sand and gravel, 8.4m thick, rests on till, but to the south of the farm the deposits are thought to be thin because pit 35 NW 295 revealed only 1.3m of gravel overlying till.

Around Yorkston a surface deposit of reddish brown till, similar to that around Arniston, is present and may conceal some sand and gravel. North of the farm mineral has not been identified. Borehole 35 NW 291 demonstrated 0.7m of fluvioglacial sand and gravel between the surface till and a basal till, but to the east a borehole [3197 5860] recorded 5.2m of sand and gravel between the two tills. Near Howburn [309 552], pit 35 NW 293 proved the surface deposit of till, to a depth of 0.7m, overlying sand and gravel which was not bottomed at 2.1m. Due to the limited number of sample points in this area, the extent and thickness of the buried sand and gravel is not sufficiently well known to be

delineated on the resource map. There is also little information concerning the thickness and composition of the exposed fluvioglacial deposits around Yorkston. In the hummocky ground south of the farm, borehole 35 NW 292 proved only 1.6m of sand and gravel overlying what was thought to be a basal till. Farther south, near Blackburn Strip, borehole 35 SW 8 penetrated 4.3m of mineral containing two beds of flow till totalling 3.4m in thickness. No other quantitative data are available on the sand and gravel deposits in the area, but observations of glacial features suggest that the sediments may in places be more thickly developed than those penetrated by the IMAU boreholes, for example in the mounds at [317 558] and [306 556]. An area around Smithy Strip [29 57] shown on the resource map, where sand and gravel deposits are buried beneath till, may be more or less extensive than indicated. In the central and eastern parts of the area mineral up to 4.1m in thickness is buried beneath up to 3.1m of till, but in the west a borehole proved 2.7m of till on sand and gravel to a depth of 30.5m. There is a lack of data on the composition of the deposits.

There are thick spreads of sand and gravel west of the Fullarton Water. In a patch of glacial sand and gravel near Ankriellaw [270 581], borehole 25 NE 137 proved 17.9m of potentially workable material overlying till, and a record of an earlier borehole drilled in the vicinity indicates that mineral was not bottomed at a depth of 19.2m. At Fullarton, borehole 25 NE 140 penetrated 6.4m of fluvioglacial sand and gravel

overlying till of which the uppermost 1.8m are regarded as potentially workable: about 200m to the north a borehole near Cauldhall [285 580] in the same deposit is reported to have proved sand and gravel to a depth of 12.8m. In borehole 25 NE 139, fluvio-glacial sediments 7.6m thick included 1.0m of laminated sandy silt grading as non-mineral. The underlying till contained a 1.3-m seam of glacial sand and gravel grading as gravel. Similar glacial-meltwater sediments were recorded in the boreholes at Fullarton and Ankielaw between two deposits of till but were not thick enough to be classified as potentially workable using the criteria adopted for this report.

Groundwater was not encountered in the potentially workable deposits in eight of the thirteen IMAU sample points that proved mineral in the block: some 82 per cent of the potentially workable sand and gravel sampled lay above the water table.

Some of the sand and gravel to the east of Temple has been removed in the course of opencast coal working but there has been no commercial exploitation as such of the resources in the block. Further information on thickness and grading is presented in Table 13 and Figure 14.

Block F

The block has a total area of 35.8km², of which 8.8km² consist of exposed mineral. The remainder is made up of areas of cropping bedrock, made ground, barren ground and small areas of concealed material. The undulating ground included in the block falls from about 250m above OD in the south-west, around Halkerston [347 583] to about 90m above OD in the valley of the Tyne Water in the north. It is deeply dissected by the Tyne Water and the upper reaches of the Gore Water, together with their tributaries; additionally, glacial drainage channels, frequently dry, indicate former water courses.

In this block fluvio-glacial sand and gravel, glacial sand and gravel and glaciolacustrine deposits are potentially workable; in addition, potentially workable sand and gravel underlies till which itself is locally mineral. The till and glaciolacustrine deposits have not been assessed. The alluvium of the Tyne Water and upper reaches of Gore Water is thought to be thin and was not investigated by IMAU boreholes.

Clay overlies sand and gravel of variable thickness over small areas north of Melvin Hall [398 685], around Vogrie [369 629], Bells Mains [345 604] and Halkerston. Some of these buried deposits may correlate with those mapped at the surface nearby. A large area of exposed till east of Crichton Mains [389 620] was proved to be generally barren.

The chief mineral-bearing deposit is the fluvio-glacial sand and gravel which forms extensive, deeply dissected terrace-like spreads and low mounds and ridges along the central axis of the block. Borehole 36 NE 306 proved 2.8m of 'very clayey' pebbly sand and 36 SE 524, 2.2m of gravel. The deposits increase in thickness and fines content southwards towards Borthwick, and vary in thickness from 4.7m to 12.5m in boreholes 36 SE 520 and 36 SE 523, respectively. In the south fluvio-glacial deposits are more variable in grading, generally thicker, and at a higher elevation than elsewhere. As may be seen from section C-C₁ on the resource map, they generally overlie glaciolacustrine deposits which, except in the basal parts of borehole 35 SE 520, have not been proved elsewhere in the block. The resource tends to comprise gravel and sandy gravel, partly

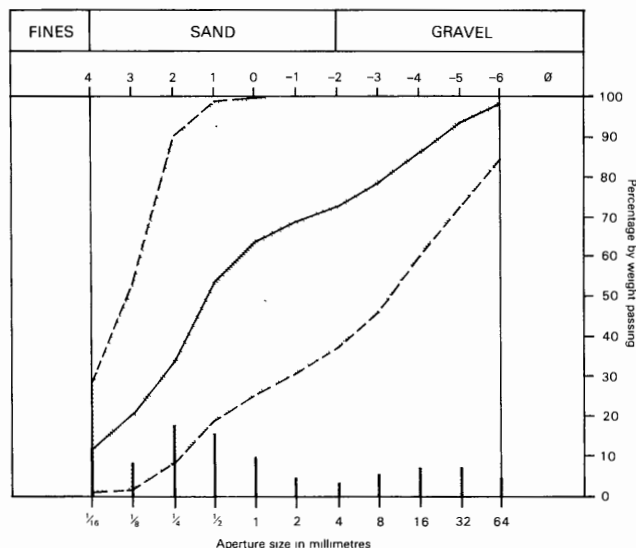


Figure 15 Grading characteristics of resources in the fluvio-glacial and glacial sand and gravel of block F; for explanation see Figure 4

'clayey' in the upper part, for example in boreholes 35 NW 299, 35 NE 28, 29, 30 and 31, whereas 'clayey', 'very clayey' and pebbly sand occur in the basal parts of, for example, boreholes 35 NE 28, 29 and 30, although the deposits in 35 NE 27 consist almost entirely of 'clayey' sand. The deposits range in thickness from 1.7m in borehole 35 NW 299 up to 13.8m in borehole 35 NE 29. Waste partings were proved in only two boreholes; 3.0m of sandy silt and 7.6m of silt and clay separated fluvio-glacial deposits in boreholes 35 NE 29 and 36 SE 520, respectively. Additionally, the mineral deposits in borehole 35 NE 28 lie beneath overburden 4.0m thick; the buried sand and gravel may correlate with similar deposits further west, as indicated on the resource map.

The resource of secondary significance is glacial sand and gravel, which, apart from 6.5m of gravel proved in borehole 36 NE 307, occurs in patches fringing the fluvio-glacial deposits and generally buried beneath overburden, for example in borehole 36 SE 520, where pebbly sand 2.3m thick was proved beneath 5.2m of till, fluvio-glacial and glaciolacustrine deposits. In borehole 36 SE 522 seams of gravel are too thin to be classified as mineral.

Soil and clay overburden ranges between 0.2 and 4.0m, for example in borehole 36 SE 521 (which penetrated fluvio-glacial sand and gravel deposits) 2.4m of soil and stony clay were proved from the surface.

Glaciolacustrine deposits do not crop out, and, except for the basal parts of borehole 36 SE 520, which proved 3.0m of 'very clayey' sand, are confined to the more elevated ground in the south of the block (see section C-C₁) where they are thought to be responsible for areas of landslip in valleys near Borthwick and North Middleton. However, areas of till mapped along the valley sides may well include the more clayey parts of the glaciolacustrine deposits. The potentially workable glaciolacustrine deposits consist chiefly of very fine-grained 'clayey' and 'very clayey' sand, pebbly in parts, and vary in thickness from 1.2m in borehole 35 NE 30 to 9.1m in borehole 35 NE 27.

Mineral-bearing deposits in this block could be worked dry because of generally low groundwater levels, especially in those boreholes lying at

Table 14 Block F: Data from sample points and the assessment of resources

Sample point	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
	Total mineral m	Depth of burial m	Inter-vening waste m	Fines $\frac{1}{2}$ mm	Fine sand $\frac{1}{2}$ - $\frac{1}{2}$ mm	Medium sand $\frac{1}{2}$ -1 mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
FLUVIOGLACIAL AND GLACIAL SAND AND GRAVEL											
35 NW 299	1.7	0.3		16	22	17	7	17	21	0	CSG
35 NE 27	5.1	0.3		18	42	22	5	8	5	0	CPS
35 NE 28	10.0	5.2*		11	23	34	10	11	10	1	CSG
35 NE 29	13.8	0.3	3.0	12	17	18	14	19	19	1	CSG
35 NE 30	3.0	0.3		5	7	22	16	26	24	0	G
35 NE 31	8.1	0.5		3	8	40	11	22	14	2	SG
36 NE 306	2.8	0.2		22	28	24	13	9	4	0	VCPS
36 NE 307	6.5	0.3		7	12	21	9	18	26	7	G
36 SE 520	7.0	0.6	7.6	10	35	42	4	5	4	0	CPS
36 SE 521	3.6	2.4		19	59	9	1	3	5	4	CPS
36 SE 523	12.5	2.0		19	47	20	5	6	3	0	CPS
36 SE 524	2.2	0.4		3	10	13	11	23	27	13	G
Mean	6.4	1.1		12	26	26	9	13	12	2	CSG
GLACIOLACUSTRINE DEPOSITS											
35 NE 27	9.1	6.7	0.4	16	79	3	1	1	**	0	CPS
35 NE 29	2.3	17.1		33	61	4	1	1	0	0	VCS
35 NE 30	1.2	3.3		32	54	6	2	3	3	0	VCPS
36 SE 520	3.0	15.2		22	65	12	1	**	0	0	VCS
Mean	3.9	10.6		21	76	3	**	**	**	0	VCS

* Includes 1.2m of potentially workable head

Statistical assessment of fluvioglacial and glacial sand and gravel

Area of exposed mineral	8.8km ²
Area of continuous or almost continuous spreads of mineral beneath overburden	0.9km ²
Total area of mineral	9.8km ²
Area of worked ground	<0.1km ²
Mean thickness of overburden	1.1m
Mean thickness of mineral	6.4m
Estimated volume of mineral	63 million m³ ±43% or 27 million m ³
Estimated yield of sand and gravel per hectare	64 thousand m³ ±43% or 28 thousand m ³

high elevations in the south. Exceptions are the areas around boreholes 35 NE 31, 36 SE 520 and 523 and 36 NE 306, where only the upper few metres were dry.

At present there are no working sand and gravel pits in this block, although numerous, small, abandoned excavations testify to former extraction for local purposes.

Further details of the potentially workable material are given in Table 14 and Figure 15.

Block G

The block comprises all of the resource sheet outside blocks A to F, much of which is upland and moorland and includes the Roman Camp Ridge and the Pentland and Moorfoot hills. Potentially workable sand and gravel deposits are scattered across the block, but they are too small, patchy and diverse to be assessed statistically. Inferred assessments are offered for deposits in three sub-blocks. Details of mean thickness and estimated volume are given in Table 15.

Sub-block G₁ The north-western part of the survey area is contained within the sub-block and borders a large built-up area forming part of southern

Edinburgh. Much of the ground is upland and includes the northern part of the Pentland Hills.

Bedrock crops out over much of the higher ground with till mantling the lower slopes. Locally small spreads of glacial meltwater deposits overlie the till, and streams flowing eastwards from the Pentland Hills have deposited alluvium in the valleys of the Boghall, Fulford and Glencorse burns.

Small patches of glacial sand and gravel flank the southern side of Caerketton Hill [236 662]: pit 26 NW 110 proved 0.9m of 'clayey' gravel. Although at this site the proved thickness is not sufficient to classify the deposit as potentially workable, generally the sand and gravel is thought to be between 1 and 2m thick and is shown as mineral on the resource map. Similar deposits are present on the southern slopes of Castlelaw Hill [225 648]. Pit 26 SW 85 at Castlelaw [230 637] demonstrated 1.2m of sediment grading as 'very clayey' sand: the full thickness of the deposit was not proved. Nearby gravel is reported to have been worked though no data are available on the thickness or composition of the deposit. Pit 26 SW 93 sampled the spread of glacial sand and gravel lying mainly to the

south of Easter Howgate [242 641]: 'clayey' sand was not bottomed at 2.0m. Although the full thickness of mineral is not known at Castelaw and Easter Howgate, the sand and gravel deposits are not thought to exceed 5m.

To the east of Boghall a spread of fluvio-glacial sand and gravel overlies a basal till. Borehole 26 NW 112 proved the deposits to a depth of 4.3m: the uppermost 3.2m graded as mineral which became finer grained with depth, passing from 'clayey' sandy gravel at the surface to laminated sandy silt at the base.

The alluvium in the valleys of the Boghall and Glencorse burns was not sampled but may be potentially workable. The field surveyor noted gravelly soil overlying the alluvial cone which surrounds Boghall. In the valley of Fulford Burn at Fulford [240 647] borehole 26 SW 90 demonstrated the alluvium to be 4.3m thick and composed of 'clayey' sandy gravel resting on a stiff basal till.

In the eastern part of the sub-block borehole 26 SE 160 penetrated a flow till, similar to that near Roslin, resting on a stiff lodgement till. Sand and gravel deposits are not thought to underlie flow till hereabouts.

Owing to the limited areal extent of the potentially workable deposits and the paucity of sample points, a statistical assessment of the mineral is not possible and separate inferred assessments are offered for the Easter Howgate and Sheriffhall areas (Table 8). Further data on the sand and gravel deposits are presented in Table 15.

Sub-block G₂ The Roman Camp Ridge dominates the sub-block, which also includes the valley of the River South Esk between Lothianbridge [326 649] and Gorebridge.

Fluvial deposits are confined to the valleys of the River North Esk, its tributary the Dalhousie Burn, and the Bellyford Burn. Small patches of fluvio-glacial sand and gravel occur at Dalhousie [320 640], near Prestonholm House [323 625] and east of Newtongrange, but are too small to be assessed in the context of this survey. The alluvial deposits occur as well developed terraces, up to three levels being recognised in the valley of the River North Esk. However, borehole 36 SW 252 sited on the highest terrace near Millholm [322 631], proved till at the surface. Nearby, on a lower terrace, pit 36 SW 251 proved 1.4m of sandy, clayey silt on sandstone, but generally the terraces are erosional features, and, if they do contain alluvial deposits, the material is likely to be non-mineral. The same may be true for the alluvium of the Bellyford Burn although a borehole [380 690] near Cousland Lime Works proved 2.6m of peat on 5.4m of gravel and sand.

Boreholes near Dalkeith Colliery [354 688] proved varying thicknesses of sand, mud and clay beneath till, but the deposits are considered to be not potentially workable on account of excessive fines or overburden. No assessments are offered for sub-block G₂.

Sub-block G₃ With a total area of 58.5km², this sub-block occupies the predominantly barren tract of ground that stretches from near Ruddenleys [205 510], in the south-west, north-eastwards towards Aikendeane [319 618]. Eight boreholes and one pit form the basis of the assessment of resources. Although mineral was proved at five sites, no statistical assessment is possible and inferred assessments are offered for the Whim [21 53] and Howgate areas (Table 8).

Extensive areas of the block consist of spreads of peat on till, which in turn overlies bedrock, for example, the areas around Blinkbonny [213 513] Auchencorth Moss, Hare Moss and west of Mount Lothian Moss [260 556]. Additionally, an area in the north of the block between Pomathorn [243 592] and Aikendeane was proved to be barren by boreholes 26 SE 166, 167 and 171, which penetrated only till. Pit 25 NW 78 proved a seam of sand and gravel classified as till, but this has been excluded from the inferred assessment.

Three areas of exposed mineral were investigated. In the south-west, patchy mounds of glacial sand and gravel, aligned approximately parallel with the A701 road, were investigated by boreholes 25 SW 14 and 15, which proved 8.4 and 4.2m of gravel, respectively. The glacial sand and gravel patches hereabouts were formerly worked in small pits for local purposes, and, because groundwater was struck in only the basal parts of both boreholes, they could be worked dry. Farther north-east, deposits of fluvio-glacial sand and gravel were investigated by pit 25 NW 78 and borehole 25 NW 79. The former proved 1.3m of 'clayey' gravel, thought to be till, whereas at the latter site 2.4m of water-saturated 'clayey' sandy gravel underlay 1.2m of overburden. In this area the fluvio-glacial deposits are thought to be thin and they overlie till, but the boundary between the two is poorly defined. Consequently these deposits are not assessed.

Boreholes 25 NW 80 and 25 NE 134 were sunk into an extensive, east-west ridge of glacial sand and gravel stretching from near Lockhart Halls Farm [235 580] to just south of Lilyburn [262 586] (see section C-C₁). The former proved 14.4m of 'very clayey' sand overlying 5.5m of 'clayey' and 'very clayey' sand. Additionally, 5.4m of silt formed waste partings in the lower parts of this borehole. Farther east the deposits in borehole 25 NE 134 are more gravelly, and 3.7m of 'clayey' gravel are separated from 8.3m of 'very clayey' sandy gravel and pebbly sand by a 0.2-m seam of clay. Beneath the pebbly sand lie 9.1m of 'clayey' sand. These in turn are underlain by 2.6m of sandy gravel. Thus, it can be expected that mineral deposits in this area will be thick and very variable in grading. They could be worked dry because groundwater levels in the boreholes were low. Overburden thickness is negligible.

In addition to mineral cropping out at the surface, there are buried sand and gravel deposits around Cauldhall Moor and Newbigging. These deposits appear to be very variable in grading, with boulder beds and clay partings. The results of the inferred assessments are given in Table 15.

Sub-block G₄ The Moorfoot Hills constitute the sub-block, together with the foothills between Tynehead [394 593] and Esperston Law [347 570] and around West Loch [257 516]. Sub-block G₄ is notably devoid of sand and gravel deposits, except for the alluvium of the Heriot Water and several small mounds of glacial sand and gravel which are too small to be assessed in this survey.

The valley of the Heriot Water has steep sides with extensive outcrops of bedrock and a flat bottom with a well developed alluvial terrace system which reaches a maximum width of 300m near Heriot.

Boreholes 35 SE 1, 2 and 3 were drilled on the floodplain and proved alluvial gravel deposits ranging in thickness from 1.1m to 3.0m: the mean is 2.2m. In boreholes 35 SE 2 and 3, 3.1m and 4.6m respectively of silt and clay, considered to be late-Glacial in age, underlay the alluvial

Table 15 Block G: Data from sample points and the assessment of resources

Sample point Borehole or pit	Recorded thickness			Mean grading percentage							Descriptive category (see the diagram in Appendix C)
	Total mineral m	Depth of burial m	Inter- vening waste m	Fines $\frac{1}{16}$ mm	Fine sand $\frac{1}{8}$ mm	Medium sand $\frac{1}{4}$ mm	Coarse sand +1 -4 mm	Fine gravel +4 -16 mm	Coarse gravel +16 -64 mm	Cobbles and boulders +64 mm	
SUB-BLOCK G ₁ (FLUVIOGLACIAL AND GLACIAL SAND AND GRAVEL AND ALLUVIUM IN THE EASTER HOWGATE AREA)											
26 NW 112	3.2	0.3		23	38	13	6	12	8	0	VCSG
26 SW 85	1.2+	0.9		32	55	8	2	2	1	0	VCS
26 SW 90	4.3	0.4		12	14	18	12	25	19	0	CSG
26 SW 93	1.2+	0.8		14	74	12	0	0	0	0	CS
Mean	2.5	0.6		18	34	14	7	15	11	0	CPS
SUB-BLOCK G ₁ (GLACIAL SAND AND GRAVEL IN THE SHERIFFHALL AREA)											
36 NW 338	1.8	0.7		38	43	8	5	5	1	0	VCPS
SUB-BLOCK G ₃ (GLACIAL SAND AND GRAVEL IN THE WHIM AREA)											
25 SW 14	8.4	0.2		9	13	15	17	20	24	2	G
25 SW 15	4.2	0.3		8	11	12	15	27	27	0	G
Mean	6.3	0.3		9	12	14	16	22	26	1	G
SUB BLOCK G ₃ (GLACIAL SAND AND GRAVEL IN THE HOWGATE AREA)											
25 NW 80	14.4	0.4	5.4	25	52	19	3	1	0	0	VCS
25 NE 134	23.7	0.3	0.2	13	35	24	5	10	11	2	CSG
Mean	19.1	0.4		18	41	22	4	7	7	1	CPS
SUB-BLOCK G ₄ (ALLUVIUM OF THE HERIOT WATER)											
35 SE 1	1.1	0.3		8	5	9	11	26	41	0	G
35 SE 2	3.0	0.2		5	4	6	12	27	36	10	G
35 SE 3	2.5	0.3		5	5	8	12	20	43	7	G
Mean	2.2	0.3		6	5	7	12	24	39	7	G
SUB-BLOCK G ₄ (GLACIAL SAND AND GRAVEL IN THE VALLEY OF THE HERIOT WATER)											
35 SE 1	9.1	1.4		5	2	9	13	30	39	2	G
35 SE 2	2.3+	6.3		11	5	7	12	20	40	5	G
Mean	5.7	3.9		6	3	9	13	28	38	3	G

Inferred assessment of the fluvioglacial and glacial sand and gravel and alluvium in the Easter Howgate area (sub-block G₁)

Area of exposed mineral 1.4km²
 Mean thickness of overburden 0.6m
 Mean thickness of mineral 2.5m
 Estimated volume of mineral 4 million m³

Inferred assessment of the glacial sand and gravel in the Sheriffhall area (sub-block G₁)

Area of exposed mineral 0.4km²
 Mean thickness of overburden 0.7m
 Mean thickness of mineral 1.8m
 Estimated volume of mineral 1 million m³

Inferred assessment of the glacial sand and gravel in the Whim area (sub-block G₃)

Area of exposed mineral 0.8km²
 Mean thickness of overburden 0.3m
 Mean thickness of mineral 6.3m
 Estimated volume of mineral 5 million m³

Inferred assessment of the glacial sand and gravel in the Howgate area (sub-block G₃)

Area of exposed mineral 1.2km²
 Mean thickness of overburden 0.4m
 Mean thickness of mineral 19.1m
 Estimated volume of mineral 22 million m³

Inferred assessment of the alluvium in the valley of the Heriot Water (sub-block G₄)

Area of exposed mineral 1.4km²
 Mean thickness of overburden 0.3m
 Mean thickness of mineral 2.2m
 Estimated volume of mineral 3 million m³

Inferred assessment of the concealed glacial sand and gravel in the valley of the Heriot Water (sub-block G₄)

Area of buried mineral 1.1km²
 Mean thickness of overburden -
 Mean thickness of mineral 5.7m
 Estimated volume of mineral* 3 million m³

* Deposit shape treated as an inverted triangular prism

deposits. In all three boreholes *gravel* or '*clayey*' *gravel*, believed to be of glacial meltwater origin, underlay the alluvium and late-Glacial alluvium. Boreholes 35 SE 1 and 2 penetrated 9.1m and 2.3m respectively of glacial sand and gravel, but in borehole 35 SE 3, *gravel*, 1.1m thick, underlay 4.6m of waste which renders the deposit not potentially workable in terms of the criteria adopted here. From these figures, it may be deduced that the deposit thins downstream; consequently an inferred boundary delimiting the extent of potentially workable, concealed glacial sand and gravel has been drawn across the valley at Borthwick Hall [387 522].

The mean grading of alluvium is fines 6 per cent, sand 22 per cent and gravel 72 per cent, comparable with the glacial sand and gravel which graded fines 6 per cent, sand 25 per cent and gravel 69 per cent. It should be noted that many of the samples were obtained from below the water table and that much of the fines were lost; for example, in borehole 35 SE 1, the first sample of glacial sand and gravel from above the water table had 10 per cent fines and the remainder contained from 3 to 5 per cent.

On the basis of the three sample points, separate inferred assessments have been calculated for the alluvium and glacial sand and gravel of sub-block G₄: the results are presented in Tables 8 and 15. For the glacial sand and gravel, it is assumed that the cross-sectional shape of the deposits equates to an inverted triangular prism, to counter the effect of siting the boreholes near the valley centre, where the deposits are assumed to be thickest.

CONCLUSIONS

The sand and gravel resources of the district have been described systematically and the results of the assessment summarised in Tables 7 and 8. It must be emphasised that the survey concerns the estimation of resources rather than reserves and that the assessment of the deposits is judged solely in terms of the arbitrary physical criteria stated in the introduction to this report. No account is taken of prevailing environmental or economic considerations: the quoted volumetric estimates bear no simple relationship to the amount of sand and gravel that might be extracted in practice. The chief aim of the survey is to provide a factual, geologically based assessment of the sand and gravel, against which the economic, social and environmental costs in developing the resource can be weighed.

Bearing in mind that much more detailed exploration and evaluation of the deposits will be required to establish the whereabouts of reserves, it is possible, nonetheless, to indicate with some degree of certainty those resources that may first command attention. These are described block by block and a generalised map summarising this information is presented in Figure 16.

Block A In block A, the sand and gravel deposits as a whole have a mean thickness of 3.2m: the mean grading is fines 14 per cent, sand 66 per cent and gravel 20 per cent. However, these figures include data from potentially workable glaciolacustrine deposits which to date have not commanded the attention of the extractive industry. If only the more immediately attractive deposits are considered (fluvioglacial sand and gravel), the resource has a mean thickness of 2.7m and a mean grading of fines 12 per cent, sand 65 per cent and gravel 23 per cent. The fluvioglacial deposits are thought to thicken to the

west of Dalkeith, where they are composed predominantly of *sand*. Elsewhere, the deposits are of fairly even thickness and generally grade as *sandy gravel*. The gravel is mainly composed of sandstone with lava and other sedimentary and igneous rock types. Overburden has a mean thickness of 0.3m.

Some of the resource has been sterilised by housing development in Dalkeith. Locally the alluvium flooring the valley of the River North Esk is potentially workable, generally ranges in thickness from one to two metres, grades as '*clayey*' *sandy gravel* and is buried beneath overburden in excess of one metre thick.

An important factor governing the development of the resource is its position relative to the water table. Considering the depth below the surface at which groundwater was first encountered, about 15 per cent of the resource beneath the fluvioglacial terraces in block A might lie below the water table as would all the mineral in the alluvium.

Although the resources in the fluvioglacial terraces could largely be worked dry, because of the limited thickness of the mineral they are not likely to receive attention from industry in the near future. It is unlikely that the alluvium would ever be considered for exploitation.

Block B The potentially workable deposits of block B are variable in thickness and composition, ranging from sand and gravel to silty sand and generally becoming finer grained with depth. They have a mean thickness of 11.5m and mean grading of fines 13 per cent, sand 77 per cent and gravel 10 per cent. However, these figures include data from the glaciolacustrine deposits which grade as '*very clayey*' *sand*. The fluvioglacial and glacial sand and gravel resources are more likely to be attractive to industry, having a mean thickness of 8.2m and mean grading of fines 10 per cent, sand 73 per cent and gravel 17 per cent. In the vicinity of the valley of the River North Esk and at Old Pentland these deposits are thickly developed, being composed predominantly of sand at the former locality and gravel and sand at the latter. The aggregate comprises sandstones and greywacke with lava and some intrusive igneous rocks and fine grained sediment.

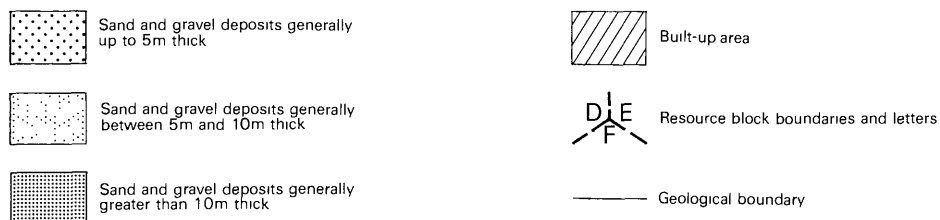
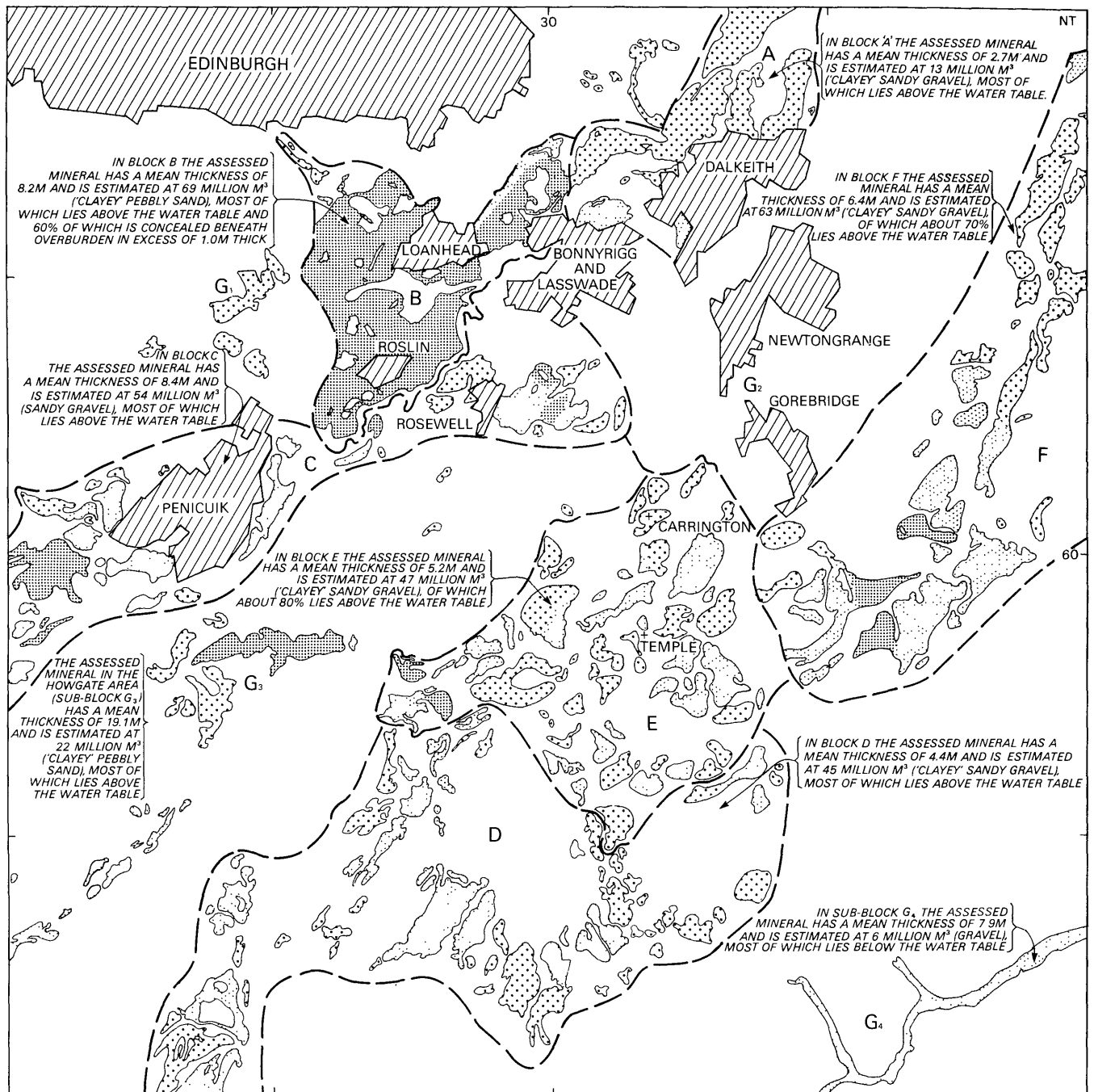
Almost two-thirds of the mineral in the block lies beneath overburden which has a mean thickness of 2.0m.

On the basis of IMAU boreholes, approximately 32 per cent of the resource is water saturated but much of that is glaciolacustrine sediment.

The resources have been worked by dry methods at a number of localities and have been extracted from beneath overburden. They are currently being dug at Melville Pit, where the material is exposed. Considering their lateral continuity and thickness, the fluvioglacial sand and gravel deposits in block B offer significant potential for further exploitation.

The alluvium in the block contains a minor resource though it is unlikely to be considered for exploitation owing to its limited areal extent and thickness and because much of it probably lies below the water table.

Block C The sand and gravel deposits in this block are variable in thickness, ranging from 2.1 to 22.6m in IMAU boreholes, but are generally similar in composition. A mean thickness of 9.1m and mean grading of fines 11 per cent, sand 63 per cent and gravel 26 per cent have been calculated for the resource as a whole, but this includes data from glaciolacustrine deposits identified in



0 5 kilometres

Figure 16 Generalised map comparing the resources and thicknesses of sand and gravel deposits in the survey area

four IMAU boreholes. The fluvioglacial and glacial sand and gravel together have a mean thickness of 8.4m and mean grading of fines 9 per cent, sand 63 per cent and gravel 28 per cent. The thickest deposits were proved to the west of Penicuik, east of Rosewell and south of Roslin. Petrographic studies indicate that the aggregate is mainly durable and composed of greywacke, lava and sandstone with porphyry, quartzite and dolerite. Overburden has a mean thickness of 0.7m.

IMAU borehole data suggest that about 86 per cent of the resource might lie above the water table.

A small amount of the resource in the block has been exploited but none is currently being worked; an appreciable amount of mineral has recently been sterilised by housing development in Penicuik. Considering its thickness and gravelly nature, the resource offers significant potential for development by dry methods, especially around Penicuik and Rosewell.

As in blocks A and B, the alluvium in block C is considered potentially workable in part but is unlikely to be considered for exploitation while more attractive prospects remain.

Block D The resources of block D are fairly uniform in thickness and comprise mainly glacial sand and gravel with a small amount of glaciolacustrine sediment. The glacial meltwater deposits have a mean thickness of 5.1m and mean grading of fines 13 per cent, sand 47 per cent and gravel 40 per cent. Considering only the glacial sand and gravel, the respective figures are 4.4m and fines 11 per cent, sand 45 per cent and gravel 44 per cent. The aggregate is composed predominantly of durable greywacke. The overburden has a mean thickness of 0.5m.

Groundwater was not encountered in thirteen of the seventeen sample points that proved mineral in the block and about 89 per cent of the mineral is estimated to lie above the water table.

The resource is currently being worked at Cowieslinn and Ship Horns. Owing to their thickness, high gravel content and their ability to be worked dry, the resources to the south and west of Gladhouse Reservoir and at Toxside, in addition to the thick sandy deposits at Esperston, may attract the attention of the extractive industry in the near future.

Block E The patches of fluvioglacial and glacial sand and gravel in block E are estimated to have a mean thickness of 5.2m. The mean grading is fines 13 per cent, sand 52 per cent and gravel 35 per cent. Over much of the block the resource is fairly uniform in thickness and composition, but south of Cauldhall Moor and north of Outerston the mineral is more thickly developed and has a higher gravel content. The aggregate is composed mainly of durable greywacke with sandstone and some lava. The overburden has a mean thickness of 0.7m.

Much of the resource could be extracted by dry working methods. Using groundwater levels measured in IMAU boreholes, 82 per cent of the potentially workable sand and gravel is estimated to lie above the water table. To date the resource in block E has not been worked on a commercial scale, but the thick gravelly deposits at Cauldhall Moor and north of Outerston offer potential for exploitation and may prove attractive to industry as other resources in the survey area are exhausted.

Block F In block F, the sand and gravel deposits

as a whole have a mean thickness of 7.7m. The mean grading is fines 14 per cent, sand 64 per cent and gravel 22 per cent. If data for the glaciolacustrine deposits are excluded, the resource has a mean thickness of 6.4m and a mean grading of fines 12 per cent, sand 61 per cent and gravel 27 per cent. The thickest deposits are developed to the south of Borthwick, where they are mainly gravelly, and around Crichton [386 620] and Vogrie; around Oxenfoord Mains the sediments are particularly gravelly. The aggregate is generally composed of greywacke with sandstone and some lava and is mainly durable. Overburden has a mean thickness of 1.1m.

From the measurement of groundwater levels in IMAU boreholes, 69 per cent of the resource is thought to lie above the water table.

A small amount of the resource has been worked in the past. Commercial exploitation of the resources in the block could be considered in the near future, particularly the thick gravelly deposits south of Borthwick and near Oxenfoord which lie mostly above the water table.

The alluvium flooring the valley of the Tyne Water is probably potentially workable in places, but is unlikely to be considered for extraction: neither is the till which locally grades as mineral.

Block G The block is divided into sub-blocks, which mainly enclose upland areas, contain only small quantities of sand and gravel and have too few sample points on which to base valid statistical assessments. The inferred volumes of mineral are of modest proportions except in sub-block G₃.

All the resources in sub-block G₁ are thin and unlikely to receive attention from the extractive industry. Sand and gravel deposits are virtually absent in sub-block G₂ and the few that are present are so small as to be uneconomic. In sub-block G₃ thick deposits of sand with gravel, forming a large ridge at Howgate, could mostly be worked by dry methods. A strip of gravelly sediment to the south-west of Leadburn lies entirely above the water table and was proved to be up to 6.4m thick in IMAU boreholes. The deposits at both localities could be considered for exploitation in the future. The resources in sub-block G₄ mainly underlie the flood plain of the Heriot Water, where boreholes penetrated a variety of deposits, composed principally of gravel, to a maximum depth of 15.4m. However, about 81 per cent of the resource is thought to lie below the water table and if, as at present, dredging operations should not be permitted, the resource is unlikely to command attention in the near future.

NOTES ON THE SAND AND GRAVEL WORKINGS IN THE AREA
The relatively large number of workings, both active and abandoned, in the resource-sheet area reveals the interest that has been focused there by the industry for many years, the prime reason for this being the proximity of the deposits to a large market in Edinburgh. A brief description of many of the pits was made by Haldane (1948); more recent information was provided by Goodlet (1970) and by McAdam (1977 and 1978). A list of the active and disused workings, which are delimited on the resource maps, is given in Table 16. Material is not known to have been extracted from below the water table, the usual intention being to back fill pits and restore the ground to agriculture subsequent to mineral extraction. Because many of the older pits have been

Table 16 List of active and disused workings

Location	Grid reference	Deposit worked	Areas of worked ground, up to February 1982, in hectares
ACTIVE			
Cowieslinn	239 516	Glacial sand and gravel	28.0
Haveral Wood	292 661	Fluvioglacial sand and gravel	4.5
Melville (incorporating Wadingburn and Melville Mains pits)	299 667	" " " "	27.7
Ship Horns	242 502	Glacial sand and gravel	13.5
DISUSED			
Bilston (2 pits)	264 641 and 267 640	Fluvioglacial sand and gravel	9.9
Borthwick	366 604	" " " "	1.0
Broomhill	309 664	" " " "	1.0
Burghlee	279 651	" " " "	4.5
Burndale	309 677	" " " "	0.8
Carsewell (2 pits)	207 599 and 211 597	Glacial sand and gravel	0.8
Castle Law (3 pits)	350 595, 354 586 and 365 594	Fluvioglacial sand and gravel	0.8
Comiston	244 689	Glacial sand and gravel	1.7
Craigburn (3 pits)	243 535, 243 528 and 244 526	" " " "	2.4
Craigpark	301 665	Fluvioglacial sand and gravel	0.8
Lugton Bogs	318 675	" " " "	1.3
England Hill (Parkburn)	300 674	" " " "	1.5
Hawthornden (Dalhousie)	299 632	" " " "	1.5
Howgate	257 582	Glacial sand and gravel	0.3
Lamancha-Whim (4 pits)	207 530, 200 524, 216 541 and 211 533	" " " "	0.6
Mortonhall	271 682	" " " "	0.6
Nether Falla	240 520	" " " "	3.0
Nivens Knowe	265 653	Fluvioglacial sand and gravel	2.0
Oatslie-Roslin (5 pits)	260 625, 263 625, 264 627, 267 628 and 269 629	" " " "	14.0
Old Pentland (2 pits)	267 660 and 270 663	" " " "	10.5
Oxenfoord (3 pits)	388 662, 390 665 and 391 665	" " " "	0.5
Parkneuk	297 630	" " " "	1.0
Pathhead	394 649	" " " "	0.5
Penicuik (2 pits)	235 602 and 237 601	" " " "	0.6
Pentland Mains	259 654	" " " "	2.0
Preston Hall (3 pits)	399 670, 396 665 and 392 661	" " " "	0.7
Rosemay, Leadburn (3 pits)	223 552, 224 552 and 226 552	Glacial sand and gravel	0.3
Rosslyn Lee	267 621	Fluvioglacial sand and gravel	1.1
Straiton	271 667	" " " "	0.6

successfully restored, the limits of the areas of worked ground shown on the resource maps may encompass some small areas which, for one reason or another, were not dug. In total, 1.41 km² of ground have been worked for sand and gravel in the survey area, that is, about 2.6 per cent of the total area of mineral-bearing ground identified in the conclusions as justifying more detailed appraisal.

REFERENCES

- ALLEN, V.T. 1936. Terminology of medium-grained sediments. *Rep. Natl. Res. Council. Washington, 1935-36, App.1, Rep. Comm. Sediment.*, 18-47.
- ARCHER, A.A. 1969. Background and problems of an assessment of sand and gravel resources in the United Kingdom. *Proc. 9th Commonw. Min. Metall. Congr., 1969, Vol. 2: Mining and Petroleum Geology*, 495-508.
- _____ 1970a. Standardisation of the size classification of naturally occurring particles. *Géotechnique*, Vol. 20, 103-107.
- _____ 1970b. Making the most of metrication. *Quarry Managers' J.*, Vol. 54, 223-227.
- ATTERBERG, A. 1905. Die rationelle Klassifikation der sande und kiese. *Chem. Ztg.*, Vol. 29, 195-198.
- BRITISH STANDARDS INSTITUTION. 1975. *BS 812: Methods of sampling and testing of mineral aggregates, sands and fillers.* 104pp. (London: British Standards Institution.)
- _____ 1975. *BS 1377: Methods for testing soils for civil engineering purposes.* 143pp., (London: British Standards Institution.)
- BUILDING RESEARCH ESTABLISHMENT. 1968. Shrinkage of natural aggregates in concrete. *Dig. Build. Res. Establ. Ser. 2, No. 35*, 7pp.
- BUREAU OF MINES AND GEOLOGICAL SURVEY. 1948. *Mineral resources of the United States*, 14-17. (Washington D.C., Public Affairs Press.)
- DHIR, R.K., RAMSAY, D.M. and BALFOUR, N. 1971. A study of the aggregate impact and crushing value tests. *J. Inst. Highway Eng.* Vol. 18, No. 11, 17-27.
- EDWARDS, A.G. 1970. Scottish aggregates: their suitability for concrete with regard to rock constituents. *Curr. Pap. Build. Res. Stn* No. 28/70.
- GOODLET, G.A. 1970. Sands and gravels of the southern counties of Scotland. *Rep. Inst. Geol. Sci.*, No. 70/4. 82 pp.
- HALDANE, D. 1948. Sands and gravels of Scotland. Quarter-inch Sheet 15: Fife-The Lothians-Berwickshire. *Wartime Pam. Geol. Surv. G.B.*, No 30.
- HARRIS, P.M., THURRELL, R.G., HEALING, R.A., and ARCHER, A.A. 1974. Aggregates in Britain. *Proc. R. Soc. London, Ser. A.*, Vol. 339, 329-353.
- HULL, J.H. 1981. Methods of calculating the volume of resources of sand and gravel. *Appendix* (pp.192-193) to THURRELL, R. G. 1981. Quarry resources and reserves: the identification of bulk mineral resources: the contribution of the Institute of Geological Sciences. *Quarry Management*, for March 1981, 181-193.
- KIRBY, R.P. 1968. The ground moraines of Midlothian and East Lothian. *Scott. J. Geol.* Vol. 4, 209-220.
- LANE, E.W., and others. 1947. Report of the sub-committee on sediment terminology. *Trans. Am. Geophys. Union*, Vol. 28, 936-938.
- LAXTON, J.L. and NICKLESS, E.F.P. 1980. The sand and gravel resources of the country around Lanark, Strathclyde Region. Description of 1:25000 resource sheet NS 94 and part of NS 84. *Miner. Assess. Rep. Inst. Geol. Sci.*, No. 49.
- MARTIN, J.H. 1981. Quaternary glaciofluvial deposits in Central Scotland: sedimentology and economic geology. Unpublished PhD thesis, University of Edinburgh.
- MCADAM, A.D. 1977. Sand and gravel resources of the Borders Region. *Rep. Inst. Geol. Sci.*, No 78/1, 18pp.
- MCADAM, A.D. 1978. Sand and gravel resources of the Lothian Region of Scotland. *Rep. Inst. Geol. Sci.*, No 78/1, 18pp.
- McMILLAN, A.A., LAXTON, J.L. and SHAW, A.J. 1981. The sand and gravel resources of the country around Dolphinton, Strathclyde Region, and West Linton, Borders Region: Description of 1:25000 resource sheets NT 04 and 14 and parts of NT 05 and 15, *Miner. Assess. Rep. Inst. Geol. Sci.*, No 62.
- MERRITT, J.W., LAXTON, J.L., SMELLIE, J and THOMAS, C.W. 1983. *Summary assesment of the sand and gravel of south-east Strathclyde, Scotland.* (Edinburgh: Institute of Geological Sciences.)
- MITCHELL, G.H. and MYKURA, W. 1962. The geology of the neighbourhood of Edinburgh. *Mem. geol. Surv. G.B.*
- PETTIJOHN, F.J. 1957. *Sedimentary rocks.* Second edition. (London: Harper and Row.)
- RAMSAY, D.M. 1965. Factors influencing aggregate impact value in rock aggregate. *Quarry Managers' J.*, Vol. 49, 129-134.
- RAMSAY, D.M., DHIR, R.K., and SPENCE, I.M. 1974. The role of rock and clast fabric in the physical performance of crushed-rock aggregate. *Eng. Geol.*, Vol. 8, 267-285.
- SHAW, A.J. and NICKLESS, E.F.P. 1981. The sand and gravel resources of the valley of the Douglas Water, Strathclyde Region: Descriptions of 1:25000 sheet NS 83 and parts of NS 82, 92 and 93. *Miner. Assess. Rep. Inst. Geol. Sci.*, No 63
- SHAW, A.J. and MERRITT, J.W. 1982. The sand and gravel resources of the country around Biggar, Strathclyde Region: Description of 1:25000 sheets NS 93 and NT 03 and parts of NS 92 and NT 02. *Miner. Assess. Rep. Inst. Geol. Sci.*, No. 95.
- THURRELL, R.G. 1971. The assessment of mineral resources with particular reference to sand and gravel. *Quarry Managers' J.*, Vol. 55, 19-25.
- _____ 1981. Quarry resources and reserves: the identification of bulk mineral resources: the contribution of the Institute of Geological Sciences. *Quarry Management*, Vol. 8, No. 3, 181-192.
- TULLOCH, W. and WALTON, H.S. 1958. The geology of the Midlothian Coalfield. *Mem. Geol. Surv. G.B.*
- TWENHOFEL, W.H. 1937. Terminology of the fine-grained mechanical sediments. *Rep. Natl Res. Council. Washington 1936-37. App. 1, Rep. Comm. Sediment*, 81-104.
- UDDEN, J.A. 1914. Mechanical composition of clastic sediments. *Bull. Geol. Soc. Am.*, Vol. 25, 655-744.
- WENTWORTH, C.K. 1922. A scale of grade and class terms for clastic sediments. *J. Geol.*, Vol. 30, 377-392.
- _____ 1935. The terminology of coarse sediments. *Bull. Natl Res. Council. Washington*, No. 98, 225-246.
- WILLMAN, H.B. 1942. Geology and mineral resources of the Marseilles, Ottawa and Streator quadrangles, *Bull. Illinois State Geol. Surv.*, No. 66, 343-344.

APPENDIX A

FIELD AND LABORATORY PROCEDURE

Trial and error during initial studies of the complex and variable glacial deposits of East Anglia and Essex showed that an absolute minimum of five sample points evenly distributed across the sand and gravel are needed to provide a worthwhile statistical assessment, but that, where possible, there should not be less than ten. Sample points are any points for which adequate information exists about the nature and thickness of the deposit and may include boreholes other than those drilled during the survey and exposures. In particular, the cooperation of sand and gravel operators ensures that boreholes are not drilled where reliable information is already available; although this may be used in the calculations, it is held confidentially by the Institute and cannot be disclosed.

The mineral shown on each 1:25000 sheet is divided into resource blocks. The arbitrary size selected, 10 km², is a compromise to meet the aims of the survey by providing sufficient sample points in each block. Where possible the block boundaries are determined by geological boundaries, but for this resource sheet area many have been drawn arbitrarily and may bear no relationship to the geology.

A reconnaissance of the ground is carried out to record any exposures, and inquiries are made to ascertain what borehole information is available. Borehole sites are then selected to provide an even pattern of sample points at a density of approximately one per square kilometre. However, because broad trends are independently overlain by smaller scale characteristically random variations, it is unnecessary to adhere to a square grid pattern. Thus such factors as ease of access and the need to minimise disturbance to land and the public are taken into account in siting the holes; at the same time it is necessary to guard against the possibility that ease of access (that is, the positions of roads and farms) may reflect particular geological conditions, which may bias the drilling results.

The drilling machine employed should be capable of providing a continuous sample representative of all unconsolidated deposits, so that the in-situ grading can be determined, if necessary, to a depth of 30m at a diameter of about 200mm, beneath different types of overburden. It should be reliable, quiet, mobile and relatively small (so that it can be moved to sites of difficult access). Shell and auger rigs have proved to be almost ideal.

The rigs are modified to enable deposits above the water table to be drilled 'dry', instead of with water added to facilitate the drilling, to minimise the amount of material drawn in from outside the limits of the hole. The samples thus obtained are representative of the in-situ grading, and satisfy one of the most important aims of the survey. Below the water-table the rigs are used conventionally, although this may result in the loss of some of the fines fraction and the pumping action of the bailer tends to draw unwanted material into the hole from the sides or the bottom.

A continuous series of bulk samples is taken throughout the sand and gravel. Ideally samples are composed exclusively of the whole of the material encountered in the borehole between stated depths. However, care is taken to discard, as far as possible, material which has caved or has been pumped from the bottom of the hole. A new sample is commenced whenever there is an

appreciable lithological change within the sand and gravel, or at every 1m depth. The samples, each weighing between 25 and 45kg, are despatched in heavy duty polythene bags to a laboratory for grading. The grading procedure is based on British Standard 1377 (1975). Random checks on the accuracy of the grading are made in the laboratories of the Industrial Minerals Assessment Unit.

All data, including mean grading analysis figures calculated for the total thickness of the mineral, are entered on standard record sheets, abbreviated copies of which are reproduced in Appendix E.

Detailed records may be consulted at the appropriate offices of the Institute: the address is shown on page ii of this report, next to the preface.

APPENDIX B

STATISTICAL PROCEDURE

Statistical assessment

1 A statistical assessment is made of an area of mineral greater than 2km², if there is a minimum of five evenly spaced boreholes in the resource block (for smaller areas see paragraph 12 below).

2 The simple methods used in the calculations are consistent with the amount of data provided by the survey. Conventional symmetrical confidence limits are calculated for the 95 per cent probability level, that is, there is a 5 per cent or one in twenty chance of a result falling outside the stated limits.

3 The volume estimate (V) for the mineral in a given block is the product of the two variables, the sampled areas (A) and the mean thickness (\bar{d}_m) calculated from the individual thicknesses at the sample points. The standard deviations for these variables are related such that

$$S_V = \sqrt{(S_A^2 + S_{\bar{d}_m}^2)}. \quad [1]$$

4 The above relationship may be transposed such that

$$S_V = S_{\bar{d}_m} \sqrt{(1 + S_A^2/S_{\bar{d}_m}^2)} \quad [2]$$

From this it can be seen that as $S_A^2/S_{\bar{d}_m}^2$ tends to 0, S_V tends to $S_{\bar{d}_m}$.

If, therefore, the standard deviation for area is small with respect to that for mean thickness, the standard deviation for volume approximates to that for mean thickness.

5 Given that the number of approximately evenly spaced sample points in the sampled area is n, with mineral thickness measurements d_{m1}, d_{m2}, \dots

d_{mn} , the the best estimate of mean thickness, \bar{d}_m , is given by

$$\sum (d_{m1} + d_{m2} \dots d_{mn})/n.$$

For groups of closely spaced boreholes a discretionary weighting factor may be applied to avoid bias (see note on weighting below). The

Block calculation

Scale: 1:25 000
Block: Fictitious

Area
Block: 11.08 km²
Mineral: 8.32 km²

Mean thickness
Overburden: 2.5 m
Mineral: 6.5 m

Volume
Overburden: 21 million m³
Mineral: 54 million m³

Confidence limits of the estimate of mineral volume at the 95 per cent probability level: ± 20 per cent
That is, the volume of mineral (with 95 per cent probability): 54 ± 11 million m³

Thickness estimate (measurements in metres)
 l_o = overburden thickness l_m = mineral thickness

Sample point	Weighting w	Overburden		Mineral		Remarks
		l_o	wl_o	l_m	wl_m	
SE 14	1	1.5	1.5	9.4	9.4	IMAU boreholes
SE 18	1	3.3	3.3	5.8	5.8	
SE 20	1	nil	-	6.9	6.9	
SE 22	1	0.7	0.7	6.4	6.4	
SE 23	1	6.2	6.2	4.1	4.1	
SE 24	1	4.3	4.3	6.4	6.4	
SE 17	$\frac{1}{2}$	1.2	1.6	9.8	7.2	Hydrogeology Unit record
123/45	$\frac{1}{2}$	2.0		4.6		
1	$\frac{1}{4}$	2.7	2.6	7.3	5.8	Close group of four boreholes (commercial)
2	$\frac{1}{4}$	4.5		3.2		
3	$\frac{1}{4}$	0.4		6.8		
4	$\frac{1}{4}$	2.8		5.9		
Totals	$\Sigma w = 8$	$\Sigma wl_o = 20.2$		$\Sigma wl_m = 52.0$		
Means		$\overline{wl_o} = 2.5$		$\overline{wl_m} = 6.5$		

Calculation of confidence limits

wl_m	$ (wl_m - \overline{wl_m}) $	$(wl_m - \overline{wl_m})^2$
9.4	2.9	8.41
5.8	0.7	0.49
6.9	0.4	0.16
6.4	0.1	0.01
4.1	2.4	5.76
6.4	0.1	0.01
7.2	0.7	0.49
5.8	0.7	0.49

$$\Sigma (wl_m - \overline{wl_m})^2 = 15.82$$

$$n = 8$$

$$t = 2.365$$

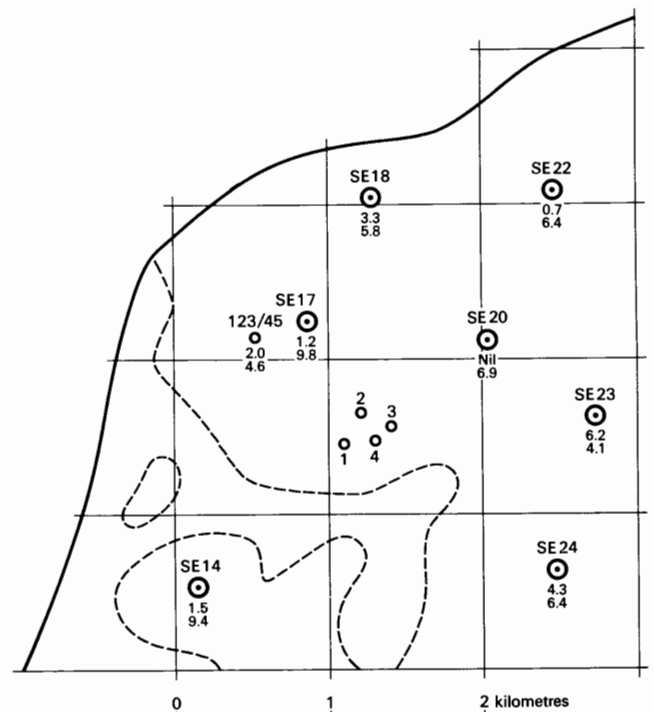
L_V is calculated as

$$1.05 (t / \overline{wl_m}) \sqrt{[\Sigma (wl_m - \overline{wl_m})^2 / n(n-1)]} \times 100$$

$$= 1.05 \times (2.365 / 6.5) \sqrt{[15.82 / (8 \times 7)]} \times 100$$

$$= 20.3$$

$$\approx 20 \text{ per cent.}$$



- SE 24 IMAU borehole
- 4.3 Overburden } Thickness in metres
- 6.4 Mineral }
- Other boreholes
- Boundary of resource block
- Boundary of sand and gravel deposit

Example of resource block assessment: map of fictitious block, calculation and results

standard deviation for mean thickness $S_{d_m}^-$ expressed as a proportion of the mean thickness, is given by

$$S_{d_m}^- = (1/\bar{d}_m) \sqrt{[\sum (d_m - \bar{d}_m)^2 / (n-1)]}$$

where d_m is any value in the series d_{m_1} to d_{m_n} .

6 The sampled area in each resource block is coloured pink on the map. Wherever possible, calculations relate to the mineral within mapped geological boundaries (which may not necessarily correspond to the limits of deposit). Where the area is not defined by a mapped boundary, that is, where the boundary is inferred, a distinctive symbol is used. Experience suggests that the errors in determining area are usually small relative to those in thickness. The relationship $S_A / S_{d_m}^- < 1/3$ is assumed in all cases. It follows

from equation [2] that $S_{d_m}^- \leq S_v \leq 1.05 S_{d_m}^-$.

7 The limits on the estimate of mean thickness of mineral, $L_{d_m}^-$, may be expressed in absolute units

$\pm (t/\sqrt{n}) \times S_{d_m}^-$ or as a percentage

$\pm (t/\sqrt{n}) S_{d_m}^- (100/\bar{d}_m)$ per cent, where t is

Student's t at the 95 per cent probability level for (n-1) degrees of freedom, evaluated by reference to statistical tables. (In applying Student's t it is assumed that the measurements are distributed normally).

8 Values of t at the 95 per cent probability level for values of n up to 20 are as follows:

n	t	n	t
1	infinity	11	2.228
2	12.706	12	2.201
3	4.303	13	2.179
4	3.182	14	2.160
5	2.776	15	2.145
6	2.571	16	2.131
7	2.447	17	2.120
8	2.365	18	2.110
9	2.306	19	2.101
10	2.262	20	2.093

(from Table 12, Biometrika Tables for Statisticians, Volume 1, Second Edition, Cambridge University Press, 1962). When n is greater than 20, 1.96 is used (the value of t when n is infinity).

9 In calculating confidence limits for volume, L_v , the following inequality corresponding to equation [3] is applied: $L_{d_m}^- \leq L_v \leq 1.05 L_{d_m}^-$.

10 In summary, for values of n between 5 and 20, L_v is calculated as

$$[(1.05t)/\bar{d}_m] \times [\sqrt{\sum (d_m - \bar{d}_m)^2 / n(n-1)}] \times 100 \text{ per cent,}$$

and when n is greater than 20, as

$$[(1.05 \times 1.96)/\bar{d}_m] \times [\sqrt{\sum (d_m - \bar{d}_m)^2 / n(n-1)}] \times 100 \text{ per cent}$$

(weighting factors may be included: see paragraph 15).

11 The application of this procedure to a fictitious area is illustrated.

Inferred assessment

12 If the sampled area of mineral in a resource block is between 0.25km² and 2km² an assessment is inferred, based on geological and topographical information usually supported by the data from one or two boreholes. The volume of mineral is calculated as the product of the area, measured from field data, and the estimated thickness. Confidence limits are not calculated.

13 In some cases a resource block may include an area left uncoloured on the map, within which mineral (as defined) is interpreted to be generally absent. If there is reason to believe that some mineral may be present, an inferred assessment may be made.

14 No assessment is attempted for an isolated area of mineral less than 0.25km².

15 **Note on weighting** The thickness of a deposit at any point may be governed solely by the position of the point in relation to a broad trend. However, most sand and gravel deposits also exhibit a random pattern of local, and sometimes considerable, variation in thickness. Thus the distribution of sample points need be only approximately regular and in estimating the mean thickness only simple weighting is necessary. In practice, equal weighting can often be applied to thicknesses at all sample points. If, however, there is a distinctly unequal distribution of points, bias is avoided by dividing the sampled area into broad zones, to each of which a value roughly proportional to its area is assigned. This value is then shared between the data points within the zone as the weighting factor.

APPENDIX C

CLASSIFICATION AND DESCRIPTION OF SAND AND GRAVEL

For the purposes of assessing resources of sand and gravel a classification should take account of economically important characteristics of the deposits, in particular the absolute content of fines and the ratio of sand to gravel.

The terminology commonly used by geologists when describing sedimentary rocks (Wentworth, 1922) is not entirely satisfactory for this purpose. For example, Wentworth proposed that a deposit should be described as a 'gravelly sand' when it contains more sand than gravel and there is at least 10 per cent of gravel, provided that there is less than 10 per cent of material finer than sand (less than 1mm) and coarser than pebbles (more than 64mm in diameter). Because deposits containing more than 10 per cent fines are not embraced by this system a modified binary classification based on Willman (1942) has been adopted.

When the fines content exceeds 40 per cent the material is not considered to be potentially workable and falls outside the definition of mineral. Deposits which contain 40 per cent fines or less are classified primarily on the ratio of sand to gravel but qualified in the light of the fines content, as follows: less than 10 per cent fines - no qualification; 10 per cent or more but less than 20 per cent fines - 'clayey'; 20 to 40 per cent fines - 'very clayey'.

The term 'clay' (as written, with single quote marks) is used to describe all material passing

$\frac{1}{16}$ mm. Thus it has no mineralogical significance and includes particles falling within the size range of silt. The normal meaning applies to the term clay where it does not appear in single quotation marks.

The ratio of sand to gravel defines the boundaries between sand, pebbly sand, sandy gravel and gravel (at 19:1, 3:1 and 1:1).

Thus it is possible to classify the mineral into one of twelve descriptive categories (see the figure at the end of this Appendix). The procedure is as follows:

- 1 Classify according to ratio of sand to gravel.
- 2 Describe fines.

For example, a deposit grading 11 per cent gravel, 70 per cent sand and 19 per cent fines is classified as 'clayey' pebbly sand. This short description is included in the borehole log (see Note 11, Appendix D).

Many differing proposals exist for the classification of the grain size of sediments (Atterberg, 1905; Udden, 1914; Wentworth, 1922; Wentworth, 1935; Allen, 1936; Twenhofel, 1937; Lane and others, 1974). As Archer (1970a,b) has emphasised, there is a pressing need for a simple metric scale acceptable to both scientific and engineering interests, for which the class limit sizes correspond closely with certain marked changes in the natural properties of mineral particles. For example, there is an important change in the degree of cohesion between particles at about the $\frac{1}{16}$ -mm size, which approximates to the generally accepted boundary between silt and sand. These and other requirements are met by a system based on Udden's geometric scale and a simplified form of Wentworth's terminology, which is used in this report. It appears at the end of this Appendix.

The fairly wide intervals in the scale are consistent with the general level of accuracy of the qualitative assessments of the resource

Classification of gravel, sand and fines

Size limits	Grain-size description	Qualification	Primary classification
64 mm	Cobble		
16 mm	Pebble	Coarse	Gravel
4 mm		Fine	
1 mm		Coarse	
$\frac{1}{2}$ mm	Sand	Medium	Sand
$\frac{1}{16}$ mm		Fine	
	Fines (silt and clay)		Fines

- I Gravel
- II 'Clayey' gravel
- III 'Very clayey' gravel
- IV Sandy gravel
- V 'Clayey' sandy gravel
- VI 'Very clayey' sandy gravel
- VII Pebbly sand
- VIII 'Clayey' pebbly sand
- IX 'Very clayey' pebbly sand
- X Sand
- XI 'Clayey' sand
- XII 'Very clayey' sand

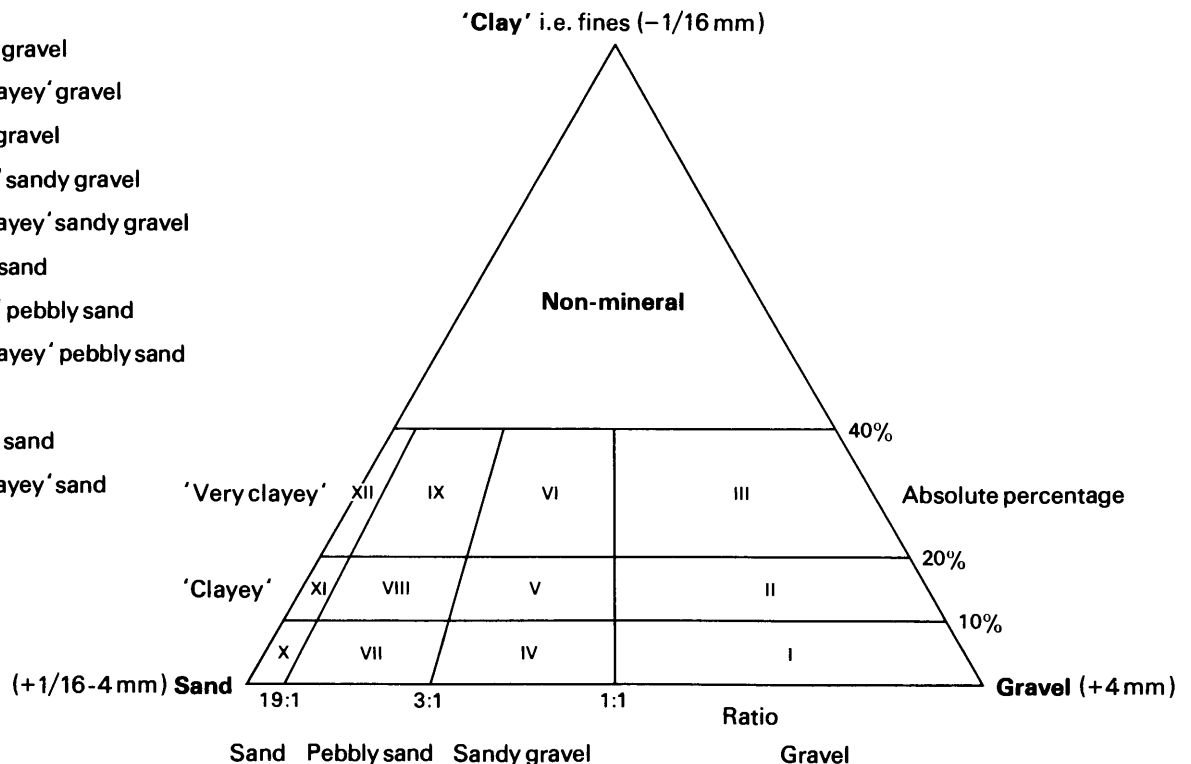


Diagram showing the descriptive categories used in the classification of sand and gravel

blocks. Three sizes of sand are recognised, fine ($+\frac{1}{8}$ - $\frac{1}{4}$ mm), medium ($+\frac{1}{4}$ -1mm) and coarse (+1-4 mm). The boundary at 16mm distinguishes a range of finer gravel (+4-16 mm), often characterised by abundance of worn tough pebbles of vein-quartz, from larger pebbles often of notably different materials. The boundary at 64mm distinguishes pebbles from cobbles. The term 'gravel' is used loosely to denote both pebble-sized and cobble-sized material.

The size distribution of borehole samples is determined by sieve analysis, which is presented by the laboratory as logarithmic cumulative curves (see, for example, British Standard 1377:1975). In this report the grading is tabulated on the borehole record sheets (Appendix E), the intercepts corresponding with the simple geometric scale $\frac{1}{8}$ mm, $\frac{1}{4}$ mm, 1 mm, 4 mm, 16 mm and so on as required. Original sample grading curves are available for reference at the appropriate office of the Institute.

Each bulk sample is described, subjectively, by a geologist at the borehole site. Being based on visual examination, the description of the grading is inexact, the accuracy depending on the experience of the observer. The descriptions recorded are modified, as necessary, when the laboratory results become available.

The relative proportions of the rock types present in the gravel fraction are indicated by the use of the words 'and' or 'with'. For example, 'flint and quartz' indicates very approximate equal proportions with neither constituent accounting for less than about 25 per cent of the whole; 'flint with quartz' indicates that flint is dominant and quartz, the principal accessory rock type, comprises 5 to 25 per cent of the whole. Where the accessory material accounts for less than 5 per cent of the whole, but is still readily apparent, the phrase 'with some' has been used. Rare constituents are referred to as 'trace'.

The terms used in the field to describe the degree of rounding of particles, which is concerned with the sharpness of the edges and corners of a clastic fragment and not the shape (after Pettijohn, 1975), are as follows

Angular: showing little or no evidence of wear; sharp edges and corners.

Subangular: showing definite effects of wear. Fragments still have their original form but edges and corners begin to be rounded off.

Subrounded: showing considerable wear. The edges and corners are rounded off to smooth curves. Original grain shape is still distinct.

Rounded: original faces completely destroyed, but some comparatively flat surfaces may still remain. All original edges and corners have been smoothed off to rather broad curves. Original shape is still apparent.

Well-rounded: no original faces, edges or corners left. The entire surface consists of broad curves; flat areas are absent. The original shape is suggested by the present form of the grain.

APPENDIX D

EXPLANATION OF THE ASSESSMENT RECORDS

Annotated example

NT 25 SE 3 ¹	2779 5297 ²	Tweeddale Burn Wood, Temple ³	Block D
Surface level +275m ⁴ (+902ft)			Overburden ⁷ 1.0m
Water struck at +272m ⁵			Mineral 0.9m
250mm percussion ⁶			Waste 0.2m
August 1982			Mineral 4.1m
			Waste 2.1m
			Bedrock 0.4m ⁹

LOG

Geological classification	Lithology	Thickness ⁸ m	Depth m
	Soil, clayey	0.3	0.3
Alluvium ¹⁰	Clay, sandy, with fine gravel sized clasts of sandstone and greywacke, moderate reddish brown (10 R 4/6)	0.7	1.0
Glacial sand and gravel	a 'Clayey' gravel ¹¹ Gravel: coarse and fine, subangular to subrounded; greywacke with trace of sandstone, siltstone and chert Sand: medium and coarse with fine, subangular; quartz and rock fragments Fines: disseminated silt and clay, moderate brown (5 YR 4/4)	0.9	1.9
	Clay, silty, laminated, firm, moderate reddish brown (10 R 4/6)	0.2	2.1
	b Gravel Gravel: fine and coarse, subangular to subrounded; greywacke with trace of andesite, sandstone, chert and vein-quartz Sand: medium and coarse with some fine, subangular to subrounded; quartz and rock fragments Fines: disseminated silt and clay, moderate brown (5 YR 4/4)	4.1	6.2
Till	Clay, sandy, stony, very stiff, moderate reddish brown (10 R 4/6) to greyish brown (5 YR 3/2) with clasts of greywacke and sandstone; below 7.4m moderate red (5 R 4/6) and with much decomposed sandstone and some coal	2.1	8.3
Carboniferous (Calcliferous Sandstone Measures)	Siltstones, slightly micaceous, hard, unbedded, moderate red (5 R 4/6)	0.4+	8.7

Grading

Mean for Deposit ¹⁵ percentages			Depth below surface (m) ¹²	percentages ¹³						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	1/16	1/8-1/4	1/4-1	+1-4	+4-16	+16-64	+64 mm
8	32	60	1.0- 1.9	14	6	12	14	25	29	0
			2.1- 3.1	9	7	12	19	38	15	0
			3.1- 4.1	12	9	14	17	28	20	0 \$ ¹⁴
			4.1- 5.1	2	2	6	16	38	36	0 \$
			5.1- 6.2	3	3	8	12	34	40	0 \$
			Mean	8	5	11	16	32	28	0

The numbered paragraphs below correspond with the annotations given on the specimen record above.

1 Borehole registration number

Each Industrial Minerals Assessment Unit (IMAU) borehole or shallow pit is identified by a registration number. This consists of two statements.

1 The number of the 1:25000 sheet on which the borehole lies, for example NT 25

2 The quarter of the 1:25000 sheet on which the borehole lies and its number in a series for that quarter for example SE 3

Thus the full registration number is NT 25 SE 3. Usually this is abbreviated to 25 SE 3 in the text.

2 The National Grid reference

All National Grid references in this publication lie within the 100-km square NT. Grid references are given to eight figures, accurate to within 10m for borehole locations. (In the text, six-figure grid references are used for more approximate locations, for example, for quarries and farms.)

3 Location

The position of the borehole is referred to the nearest named locality on the 1:25000 base map, followed by the name of the parish. The resource block in which it lies is also stated.

4 Surface level

The surface level at the sample point is given in metres above Ordnance Datum. Measurements were made in metres, approximate conversions to feet are given in brackets. Sites of boreholes and most pits were levelled from either spot heights or bench marks, the precision of the figure reflecting the nature of the point of origin. The surface levels of the remaining pit sites were estimated from contours on 1:10000 and 1:10560 sheets and are probably accurate to plus or minus two metres; such elevations are prefixed by the letter 'c'.

5 Groundwater conditions

If groundwater was present the level at which it was either encountered or statically measured is normally given (in metres above Ordnance Datum).

6 Method and date of sampling

Modified shell and auger rigs were used for the drilling of boreholes in this survey. The drilling method, the external diameter of the casing used, and the month and year of completion of the borehole are given. Where appropriate other methods of sampling are stated (for example, sampling by hand).

7 Overburden, mineral, waste and bedrock

Mineral is sand and gravel which, as part of a deposit, falls within the arbitrary definition of potentially workable material (see p. 1). The summary of mineral thicknesses may include waste partings: the aggregated waste thickness is given in brackets and has been excluded in the assessment of resources. Consequently mineral thicknesses given in Tables 9 to 15 may not correspond precisely with the logs. Bedrock is the 'formation', 'country rock' or 'rock head' below which potentially workable sand and gravel will not be found. Waste is any material other than bedrock or mineral. Where waste occurs between the surface and mineral it is classified as overburden.

8 Thickness and depth

All measurements were made in metres.

9 The plus sign (+) indicates that the base of the deposits was not reached during drilling or sampling.

10 Geological classification

The geological classification is given whenever possible.

11 Lithological description

When sand and gravel is recorded a general description based on the mean grading characteristics (for details see Appendix C) is followed by more detailed particulars. The description of other rocks is based on visual examination, in the field. Details of colour are based on the Rock-color Chart distributed by the Geological Society of America: the colour is followed by the relevant colour code.

12 Sampling

A continuous series of bulk samples is taken through the thickness of sand and gravel. A new sample is commenced whenever there is an appreciable lithological change within the sand and gravel or ideally at every 1m of depth.

13 Grading results

The results are expressed as per cent by weight retained on British Standard sieves whose aperture sizes are given in millimetres or fractions thereof.

14 Bailed samples

Fully representative sampling of sand and gravel is difficult to achieve, particularly where groundwater levels are high. Comparison between boreholes and adjacent exposures suggests that in borehole samples the proportion of sand may be higher and the proportion of fines and coarse gravel (+16mm) may be lower. Samples obtained by the bailing technique (that is, from deposits below the water table) are indicated thus: §.

15 Mean grading

The grading of the full thickness of the mineral deposit identified in the log is the mean of the individual sample gradings weighted by the thickness represented. The classification used is shown in the Table in Appendix C. Where two or more distinct mineral units form continuous sequences, the mean gradings of these are also given under each unit. Trace amounts are indicated thus: **. For multiple mineral units, each is designated by a letter, for example, a, b etc.

APPENDIX E

INDUSTRIAL MINERALS ASSESSMENT UNIT BOREHOLE AND
SHALLOW PIT RECORDS

NT 25 NW 74

2075 5938

Carsewell, Penicuik

Block C

Surface level +253.6m
(+832.0ft)
Water struck (perched) at
+252.2m
250mm percussion
August 1982

Overburden 0.8m
Mineral 3.1m
Waste 7.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, pebbly, moderate brownish grey	0.4	0.4
Head	Clay, sandy and silty, firm, reddish brown, with angular to subangular fragments of red and yellow sandstones and coal	0.4	0.8
Fluvioglacial sand and gravel	a 'Very clayey' pebbly sand Gravel: fine and coarse with rare cobbles, subrounded to well rounded; yellow and white sandstones with coal, shale, andesite, vein-quartz and rare greywacke and felsite Sand: fine with medium and some coarse, subangular to subrounded; quartz with some rock fragments Fines: silt, disseminated but in seams from 1.6 to 2.0m, moderate brown (5 YR 3/4)	2.0	2.8
	b 'Clayey' sandy gravel Gravel: fine and coarse with rare cobbles, angular to rounded; grey, cream and red sandstones with felsite, quartzite, andesite, vein-quartz, shale and rare schist, dolerite and psammite Sand: fine with medium and coarse, subangular to subrounded; quartz with rock fragments, feldspar and coal Fines: moderate yellowish brown (10 YR 5/4) silt and clay binding the deposit	1.1	3.9
Till	Clay, stony, stiff, dusky yellowish brown (10 YR 2/2), with clasts of grey, red and cream sandstones, quartzite, limestone, carbonaceous shale, coal, greenstone, granite, felsite and basalt	7.1+	11.0

Borehole abandoned owing to slow progress

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand	Gravel					
				from	to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$ mm
a	23	67	10	0.8- 1.8	20	50	26	2	2	0	0	
				1.8- 2.8	25	37	17	5	9	7	0	\$
				Mean	23	43	21	3	6	4	0	
b	11	49	40	2.8- 3.9	11	25	18	6	17	23	0	\$
a&b	18	61	21	Mean	18	37	20	4	10	11	0	

Surface level c+247m
(c+811ft)
Water not struck
250 and 200mm percussion
August 1982

Overburden 0.2m
Mineral 2.7m
Waste 1.7m
Mineral 1.0m
Waste 4.1m
Bedrock 0.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, pale brown	0.2	0.2
Glacial sand and gravel	a Gravel Gravel: fine and coarse with some cobbles, subangular to rounded; cream and red sandstones and andesite with quartzite, vein-quartz, felsite, ironstone and greywacke Sand: fine, medium and coarse, subangular to subrounded; quartz and rock fragments Fines: disseminated silt and clay, moderate brown (5 YR 4/4)	2.7	2.9
Glaciolacustrine deposits	Silt, laminated and with scattered pebbles; sandy towards base, moderate brown (5 YR 4/4)	1.7	4.6
	b 'Very clayey' sand with rare fine gravel Sand: fine, with some medium, subangular to subrounded; quartz, feldspar and rock fragments with some coal Fines: thin seams of moderate brown (5 YR 4/4) silt	1.0	5.6
	Silt, moderate brown (5 YR 4/4) laminated and sandy, with some pebbles of sandstone, quartz, andesite, dolerite and porphyry; some clay laminae and coal fragments. Also solifluction deposits of stony clay less than 0.1m thick	1.9	7.5
Till	Clay, stony, greyish brown (5 YR 3/2) to dusky brown (5 YR 2/2) and very hard, but soft and dark reddish brown below 8.9m; contains subrounded pebbles of red and white sandstones, greywacke, basalt and andesite with vein-quartz; increasing proportions of red sandstone below 8.9m	2.2	9.7
Carboniferous (Limestone Coal Group)	Coal, weathered at top, with grey seatearth	0.9+	10.6

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand		Gravel			
						from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16
a	9	37	54	0.2- 1.2	8	8	17	15	23	20	9
				1.2- 2.2	9	8	17	13	25	28	0
				2.2- 2.9	12	12	14	8	20	27	7
				Mean	9	9	16	12	23	26	5
b	26	73	1	4.6- 5.6	26	61	12	0	1	0	0
a&b	14	47	39	Mean	14	23	15	9	17	18	4

Surface level c+254m
(c+834ft)
Water not struck
250mm percussion
September 1982

Overburden 0.2m
Mineral 1.8m
Waste 1.0m
Mineral 2.0m
Waste 0.5m
Mineral 2.7m
Waste 2.2m
Bedrock 0.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pale, sandy and pebbly	0.2	0.2
Glacial sand and gravel	a Gravel Gravel: fine with some coarse, subangular to rounded; andesite and greywacke with sandstone, felsite, chert, quartz and conglomerate Sand: medium and coarse with some fine, angular to rounded; quartz and rock fragments Fines: silt	0.8	1.0
Glaciolacustrine deposits	b 'Very clayey' sand Sand: fine, angular to rounded; quartz and rock fragments Fines: seams of reddish brown micaceous silt	1.0	2.0
	Silt, very sandy, reddish brown, micaceous	1.0	3.0
	c 'Very clayey' sand Sand: fine with some medium, angular to rounded; quartz and rock fragments Fines: seams of moderate brown (5 YR 3/4) micaceous silt	2.0	5.0
	Silt, moderate brown (5 YR 3/4), very sandy, micaceous	0.5	5.5
	d 'Very clayey' sand Sand: fine with medium, angular to rounded; quartz and rock fragments Fines: silt seams, moderate brown	1.0	6.5
Glacial sand and gravel	e Sandy gravel Gravel: fine with coarse, subangular to well rounded; red and yellow sandstones with greywacke, grit, conglomerate, andesite, dolerite, felsite, quartzite and vein-quartz Sand: medium with fine and coarse, angular to rounded; quartz and rock fragments Fines: silt	1.7	8.2
Till	Clay, stony, stiff and pebbly in parts, softer and more sandy in others, moderate brown (5 YR 4/4) to moderate reddish brown (10 YR 4/6), containing fine, coarse and cobble gravel sized erratics of rounded reddened limestone, andesite, yellowish sandstone, rotted lavas, mudstone and coal	2.2	10.4
Carboniferous (Passage Group)	Sandstone, yellowish, friable at top, becoming harder with depth	0.7+	11.1

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages								
	Fines	Sand	Gravel		from	to	Fines		Sand		Gravel		
							$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
a	4	45	51	0.2-	1.0	4	5	25	15	40	11	0	
b	28	70	2	1.0-	2.0	28	66	3	1	2	0	0	
c	22	78	0	3.0-	5.0	22	68	10	**	**	0	0	
d	23	77	0	5.5-	6.5	23	60	16	1	**	0	0	
e	6	60	34	6.5-	8.2	6	11	39	10	20	14	0	
b-d	24	75	1	Mean		24	65	10	**	1	0	0	
a&e	6	55	39	Mean		6	9	34	12	26	13	0	
a-e	17	68	15	Mean		17	44	19	5	10	5	0	

Surface level +224.7m
 (+737.2ft)
 Groundwater level +204.9m
 250 and 200mm percussion
 August 1982

Overburden 0.4m
 Mineral 16.1m
 Waste 1.2m
 Mineral 6.1m
 Waste 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pebbly, sandy	0.4	0.4
Fluvioglacial sand and gravel	a Sandy gravel Gravel: fine and coarse with rare cobbles, subangular to subrounded; cream and red sandstones, quartz, andesite, basalt, felsite, dolerite and quartzite with some chert and mica-schist Sand: medium and coarse with some fine, subangular to subrounded; quartz, with feldspar and rock fragments Fines: silt, disseminated with rare seams, moderate brown (5 YR 4/4)	4.4	4.8
	b Pebbly sand Gravel: fine and coarse, subangular to rounded; chiefly cream sandstone with coal Sand: fine and medium with a little coarse, subangular to subrounded; quartz with coal, some rock fragments, mica and feldspar Fines: moderate yellowish brown (10 YR 5/4) silt, disseminated but with seams below 8.5m	8.0	12.8
Glaciolacustrine deposits	c 'Very clayey' sand, with rare pebbles of andesite, sandstone, felsite, vein-quartz and coal Sand: fine with some medium, angular to subrounded; quartz with mica, feldspar and some coal Fines: light brown (5 YR 5/4) disseminated silt	3.7	16.5
	Silt and clay, 0.1m firm pale brown (5 YR 5/2) stony clay on pale brown (5 YR 5/2) laminated silt with clay and sand seams	1.2	17.7
	d 'Very clayey' sand Sand: fine with some medium, subangular; quartz with some coal, feldspar, rock and mica fragments Fines: silt, disseminated, dark yellowish brown (10 YR 4/2)	1.5	19.2
Glacial sand and gravel	e Pebbly sand Gravel: present below 23.2m, fine and coarse with rare cobbles, angular to rounded; sandstone, andesite, coal, felsite, and vein-quartz Sand: fine and medium with rare coarse, subangular to subrounded; quartz with some coal, feldspar, rock and mica fragments Fines: disseminated silt and seams up to 30mm thick of silt with clay, moderate brown (5 YR 4/3) to 23.2m, dark yellowish brown (10 YR 4/3) below	4.6	23.8
Till	Clay, stony, stiff, greyish brown (5 YR 4/2); clasts chiefly of sandstones and andesitic lava with quartz, felsite and coal	1.2+	25.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand		Gravel			
				from to	- $\frac{1}{8}$	+ $\frac{1}{8}$ - $\frac{1}{4}$	+ $\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
a	5	57	38	0.4- 1.4	5	4	28	22	27	14	0
				1.4- 2.5	4	5	35	21	21	14	0
				2.5- 3.6	4	4	30	29	20	13	0
				3.6- 4.8	8	13	16	20	23	20	0
				Mean	5	7	27	23	23	15	0
b	6	86	8	4.8- 6.0	11	34	42	6	6	1	0
				6.0- 7.4	4	23	27	18	21	7	0
				7.4- 8.5	6	34	47	5	5	3	0
				8.5- 9.5	7	47	42	1	3	0	0
				9.5-10.8	4	59	37	0	0	0	0
				10.8-11.8	9	72	19	0	0	0	0
				11.8-12.8	6	39	47	3	4	1	0
Mean	6	44	37	5	6	2	0				
c	24	76	0	12.8-14.0	17	66	16	1	0	0	0
				14.0-15.1	20	75	5	0	0	0	0
				15.1-16.5	33	63	4	0	0	0	0
				Mean	24	68	8	**	**	0	0
d	31	69	0	17.7-19.2	31	64	5	0	0	0	
e	7	88	5	19.2-20.4	5	72	22	1	0	0	0
				20.4-22.5	4	62	34	0	0	0	0
				22.5-23.2	9	83	7	1	0	0	0
				23.2-23.8	23	30	7	3	16	21	0
				Mean	7	64	23	1	2	3	0
a&b	6	75	19	Mean	6	30	33	12	12	7	0
c&d	26	74	0	Mean	26	67	7	**	**	0	0
a&b&e	6	79	15	Mean	6	39	31	9	9	6	0
a-e	11	78	11	Mean	11	46	25	7	7	4	0

Surface level c+236m
 (c+775ft)
 Water struck at c+234m
 Pit
 August 1982

Overburden 0.3m
 Mineral 1.3m
 Waste 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, clayey, moderate brown	0.3	0.3
Till	'Clayey' gravel Gravel: coarse with fine and cobbles, red, yellow and brown sandstones, greywacke, siltstone, grit, quartz, felsite, andesite, quartzite, coal, ironstone nodules and diorite Sand: fine with medium and coarse, quartz and rock fragments, moderate to greyish brown Fines: disseminated silt and clay	1.3	1.6
	Clay, stony, stiff, reddish brown, with angular to subrounded clasts of sandstone, greywacke, siltstone, shale, coal, vein-quartz and felsite	0.4+	2.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{8}$	$+\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
15	42	43	0.3-	1.6	15	22	13	7	12	23	8

Surface level +245.0m
 (+803.8ft)
 Water struck at +243.8m
 250 and 200mm percussive
 August 1982

Overburden 1.2m
 Mineral 2.4m
 Waste 9.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pale brown	0.2	0.2
Alluvium	Clay, moderate brown (5 YR 4/4) to light brown (5 YR 5/6), soft, with sand lenses, silt stringers, rootlets and mica, damp and sandy towards base	1.0	1.2
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: coarse, fine and cobble, subangular to well rounded; greywacke, red, yellow and dark coloured sandstones with some basalt, porphyry, tuff, coal and chert Sand: fine with medium and coarse, subangular to rounded; quartz and rock fragments with some coal debris Fines: seams of greyish brown, micaceous silt	2.4	3.6
Till	Clay, stony, soft, silty and unconsolidated at top but harder below 4.0m, moderate brown (5 YR 3/4), contains subangular to well rounded pebbles and cobbles of grit, greywacke and volcanic rocks; clay softer and damp below 5.0m. Below 8.0m colour greyish brown (5 YR 3/2) to moderate brown (5 YR 3/4), very hard and with large rounded pebbles of green muddy sandstone and cream quartzite	9.8+	13.4

Borehole abandoned owing to lack of progress

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	- $\frac{1}{8}$	+ $\frac{1}{8}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
17	47	36	1.2- 2.4	19	36	12	6	10	17	0 §
			2.4- 3.6	15	25	9	7	13	14	17 §
			Mean	17	29	11	7	12	16	8

Surface level +258.0m
 (+846.5ft)
 Groundwater level +235.0m
 250 and 200mm percussion
 September 1982

Overburden 0.4m
 Mineral 14.4m
 Waste 3.7m
 Mineral 1.5m
 Waste 1.7m
 Mineral 4.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, light, sandy, pebbly loam	0.4	0.4
Glacial sand and gravel	a 'Very clayey' sand, with subangular to subrounded pebbles of sandstone, andesite, vein-quartz and coal between 8.4 and 10.1m Sand: fine with some medium and a little coarse, fining slightly downwards, subangular to subrounded; quartz with rock fragments, feldspar and some coal Fines: silt, chiefly in seams and clay films which are more common at depth, pale yellowish brown (10 YR 6/2) to moderate brown (5 YR 4/4)	14.4	14.8
Glaciolacustrine deposits	Silt, very sandy with clay laminae, dark to moderate yellowish brown (10 YR 4/2 to 10 YR 5/4)	3.7	18.5
	b 'Very clayey' sand Sand: fine with some medium, angular to subrounded; quartz with feldspar, coal, mica and rare rock fragments Fines: disseminated silt and clay films and laminae, dark to moderate yellowish brown (10 YR 4/2 to 10 YR 5/4)	1.5	20.0
	Silt, very sandy, with clay laminae, dark to moderate yellowish brown	1.7	21.7
	c 'Clayey' sand Sand: fine with some medium and coarse, subangular to rounded; quartz with feldspar, coal, rock fragments and rare mica Fines: disseminated silt, dark yellowish brown (10 YR 4/3)	4.0+	25.7

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	- $\frac{1}{8}$	$+\frac{1}{8}$ - $\frac{1}{4}$	$+\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
a	25	74	1	0.4- 1.4	29	64	4	1	2	0	0
				1.4- 2.4	21	71	6	1	1	0	0
				2.4- 3.9	27	62	8	2	1	0	0
				3.9- 5.4	12	46	31	9	2	0	0
				5.4- 6.9	13	66	18	2	1	0	0
				6.9- 8.4	7	43	46	4	0	0	0
				8.4-10.1	36	36	21	5	2	0	0
				10.1-11.5	36	51	12	1	0	0	0
				11.5-13.2	35	38	22	3	2	0	0
				13.2-14.8	26	59	14	1	0	0	0
			Mean	25	52	19	3	1	0	0	
b	35	65	0	18.5-20.0	35	55	10	0	0	0	0
c	15	85	0	21.7-23.2	20	71	9	0	0	0	0
				23.2-25.7	12	72	16	0	0	0	0
				Mean	15	72	13	**	0	0	0
b&c	21	79	0	Mean	21	67	12	**	0	0	0
a-c	23	76	1	Mean	23	57	17	2	1	0	0

Surface level +272m
 (+892ft)
 Groundwater level +254m
 250 and 200mm percussion
 September 1982

Overburden 0.3m
 Mineral 3.7m
 Waste 0.2m
 Mineral 20.0m
 Bedrock 0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark brown, sandy and pebbly	0.3	0.3
Glacial sand and gravel	a 'Clayey' gravel Gravel: coarse and fine with some cobbles, subangular to well rounded; chiefly brown and white sandstones with dolerite, andesite, mudstone, greywacke and sporadic quartz and ironstone Sand: fine with medium and coarse, rounded; quartz and rock fragments Fines: brown silt and clay binding the deposit in parts	3.7	4.0
	Clay, stiff, laminated in parts, moderate brown to dark grey, contains sand lenses and small sandstone and mudstone pebbles	0.2	4.2
	b 'Very clayey' sandy gravel Gravel: fine and coarse with some cobbles, subangular to well rounded; sandstone, greywacke and siltstone with some andesite, felsite, dolerite and sporadic quartz Sand: chiefly fine, rounded, quartz and rock fragments Fines: brown, micaceous silt and 'binding' clay	6.2	10.4
	c Pebbly sand Gravel: fine and coarse, components as above Sand: fine and medium, components as above Fines: silt and clay	2.1	12.5
	d 'Clayey' sand, with a few siltstone and sandstone pebbles and coal debris Sand: fine with medium, rounded; quartz and rock fragments Fines: disseminated brown micaceous silt	9.1	21.6
	e Sandy gravel Gravel: fine and coarse with some cobbles, angular to well rounded; sandstone, greywacke and conglomerates with dolerite, andesite, felsite and sporadic quartz and siltstone Sand: chiefly medium, rounded; quartz and rock fragments Fines: brown silt	2.6	24.2
Carboniferous (Limestone Coal Group)	Sandstone, whitish, feldspathic and friable, with iron staining and coal debris	0.8+	25.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages								
	Fines	Sand	Gravel		from	to	Fines		Sand		Gravel		
							$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$ mm
a	13	38	49	0.3-	1.3	14	17	15	13	22	19	0	
				1.3-	2.4	16	21	13	7	15	28	0	
				2.4-	3.2	9	16	12	6	15	34	8	
				3.2-	4.0	13	12	9	10	17	26	13	
				Mean		13	17	12	9	17	27	5	
b	23	44	33	4.2-	5.3	31	28	16	6	10	9	0	
				5.3-	6.3	24	21	14	10	18	13	0	
				6.3-	7.3	21	22	8	6	11	17	15	
				7.3-	8.3	28	22	7	7	14	12	10	
				8.3-	9.3	23	29	8	7	16	12	5	
				9.3-	10.4	20	20	16	9	17	18	0	
				Mean		23	24	12	8	14	14	5	
c	7	73	20	10.4-	11.4	9	17	40	9	12	13	0	
				11.4-	12.5	5	42	34	3	7	9	0	
				Mean		7	30	37	6	9	11	0	
d	10	90	0	12.5-	13.5	4	26	70	0	0	0	0	
				13.5-	14.5	12	49	39	0	0	0	0	
				14.5-	15.5	10	87	3	0	0	0	0	
				15.5-	16.5	18	52	29	1	0	0	0	
				16.5-	17.5	8	31	54	5	2	0	0	
				17.5-	18.5	10	84	6	0	0	0	0	
				18.5-	19.5	7	78	15	0	0	0	0	
				19.5-	20.5	10	24	64	2	0	0	0	
				20.5-	21.6	11	66	23	0	0	0	0	
				Mean		10	55	34	1	**	0	0	
e	5	48	47	21.6-	22.6	5	14	24	9	26	22	0	
				22.6-	24.2	5	11	27	11	19	27	0	
				Mean		5	12	26	10	22	25	0	
a&b	20	42	38	Mean		20	22	12	8	15	18	5	
a-c	18	47	35	Mean		18	23	16	8	14	17	4	
a-d	15	65	20	Mean		15	36	24	5	8	10	2	
b-d	15	71	14	Mean		15	41	26	4	6	6	2	
a-e	13	64	23	Mean		13	35	24	5	10	11	2	

Surface level +267m
 (+876ft)
 Water seepage at +264m
 250mm percussion
 September 1982

Overburden 0.3m
 Mineral 1.8m
 Bedrock 1.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy, pebbly	0.3	0.3
Glacial sand and gravel	'Clayey' sandy gravel Gravel: fine and coarse, subangular to well rounded; sandstone, greywacke, siltstone and andesite Sand: fine with medium and coarse, rounded; quartz and rock fragments Fines: grey and brown micaceous, silty clay binding the deposit in places	1.8	2.1
Carboniferous (Lower Limestone Group)	Sandstone, pale brown and whitish, iron stained in parts, friable, with sporadic carbonaceous debris	1.1+	3.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
			from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
19	41	40	0.3- 0.9	27	36	15	6	8	8	0
			0.9- 1.5	12	8	7	13	31	29	0
			1.5- 2.1	17	14	10	14	25	20	0
			Mean	19	19	11	11	21	19	0

Surface level +274m
 (+899ft)
 Water not struck
 250 and 200mm percussion
 August 1982

Overburden 0.2m
 Mineral 2.6m
 Waste 15.5m
 Bedrock 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, gravelly	0.2	0.2
Glacial sand and gravel	Gravel Gravel: coarse and fine with rare cobbles, subangular to subrounded; chiefly greywacke with rare andesite, felsite, quartz, chert and ironstone Sand: coarse with fine and medium, subangular; quartz and rock fragments Fines: disseminated silt and clay, moderate brown (5 YR 4/4)	2.6	2.8
Till	Clay, stony, very hard, moderate reddish brown (10 R 4/6) to 10m, moderate red (5 R 4/6) below, with subangular to subrounded pebbles of sandstone, limestone, greywacke and coal and below 10m red sandstone fragments	15.5	18.3
Carboniferous (Calcliferous Sandstone Measures)	Sandstone and siltstone, alternations of moderate red (5 R 4/6) silty sandstone, greenish grey, micaceous siltstone and greenish grey, micaceous, silty sandstone	0.3+	18.6

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
7	30	63	0.2- 1.2	3	3	9	12	24	49	0
			1.2- 2.2	8	5	10	16	24	37	0
			2.2- 2.8	10	7	12	18	28	25	0
			Mean	7	5	10	15	25	38	0

Surface level +273.7m
(+898.0ft)
Groundwater level at 253.5m
250 and 200mm percussion
August 1982

Overburden 0.2m
Mineral 17.9m
Waste 6.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pale brown, sandy	0.2	0.2
Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: fine and coarse with some cobbles, subangular to rounded; sandstones, greywacke, siltstone, andesite, dolerite, basalt, quartz, felsite, limestone, chert and coal fragments Sand: medium with fine and coarse, subangular to subrounded; quartz, rock fragments, feldspar and coal Fines: disseminated and 'binding' silt and clay, moderate brown (5 YR 4/4) to dark yellowish brown (10 YR 4/2)	10.4	10.6
	b 'Clayey' sand, with a few small pebbles Gravel: rare fine and trace of coarse, subangular to rounded; sandstone and andesite with greywacke and coal Sand: fine with some medium, subangular to subrounded; quartz with rock, coal and feldspar Fines: silt, disseminated and in seams, yellowish brown (10 YR 6/2)	5.1	15.7
	c Gravel Gravel: fine and coarse with some cobbles, subangular to rounded; sandstone, quartzite, greywacke, andesite, dolerite, felsite, quartz, siltstone, limestone and coal fragments Sand: coarse with medium and fine, subangular to subrounded; quartz, rock, feldspar and coal Fines: silt, disseminated, dusky yellowish brown (10 YR 3/2)	2.4	18.1
Till	Clay, stony, greyish brown (5 YR 3/2) to olive black (5 R 2/1), very stiff, with large clasts of cream and red sandstones, andesite and dolerite; smaller clasts of ironstone, felsite, shale, mudstone, impure limestone, vein-quartz, coal and basalt	4.0	22.1
Glacial sand and gravel	Gravel Gravel: fine and coarse with rare cobbles, chiefly angular to subangular; sandstones and greywacke with ironstone, limestone and rare felsite Sand: coarse with medium and fine, angular to subrounded; quartz, rock fragments, feldspar and coal Fines: moderate yellowish brown (10 YR 5/4) silt and clay, disseminated and in thin seams	0.9	23.0
Till	Clay, stony, silty, dark yellowish brown, (10 YR 4/2), firm to stiff, with pebble and rare cobble-sized clasts of greywacke and andesite with rare Carboniferous sediments	1.1+	24.1
Borehole terminated owing to excessive overburden			

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
a	10	55	35	0.2- 1.5	14	37	30	8	5	6	0
				1.5- 2.5	7	14	22	22	23	12	0
				2.5- 3.5	12	17	28	13	18	12	0
				3.5- 4.5	8	10	35	15	17	15	0
				4.5- 5.5	9	8	17	18	25	23	0
				5.5- 6.8	11	7	10	17	32	23	0
				6.8- 7.8	9	27	47	6	8	3	0
				7.8- 8.8	10	14	10	11	20	22	13
				8.8- 9.8	10	11	18	15	24	18	4
				9.8-10.6	11	8	31	18	22	10	0
			Mean	10	16	25	14	19	14	2	
b	15	84	1	10.6-11.6	9	40	48	2	1	0	0
				11.6-12.4	22	67	8	2	1	0	0
				12.4-13.4	20	47	23	5	4	1	0
				13.4-14.5	15	44	40	1	0	0	0
				14.5-15.7	13	72	11	3	1	0	0
							Mean	15	55	26	3
c	6	42	52	15.7-17.2	8	9	19	19	23	22	0
				17.2-18.1	2	5	8	20	38	27	0
							Mean	6	8	15	19
a&c	9	53	38	Mean	9	14	24	15	21	16	1
a-c	11	61	28	Mean	11	25	24	12	15	12	1

Surface level +265m
(+869ft)
Water not struck
250mm percussion
August 1982

Overburden 0.1m
Mineral 6.1m
Waste 4.3m
Bedrock 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, medium brown, pebbly, sandy and silty	0.1	0.1
Glacial sand and gravel	a Gravel Gravel: coarse and fine with some cobbles, subrounded to well rounded; predominantly greywacke with some mudstone, quartzite, quartz, felsite and rare sandstone Sand: coarse and fine with some medium, subangular to rounded, greyish brown (5 YR 3/2); quartz with rock fragments Fines: disseminated silt	5.0	5.1
Till	b 'Very clayey' sandy gravel Gravel: fine and coarse with some cobbles, angular to rounded; greywacke with red and yellow sandstones, siltstone, dolerite, felsite, quartz, shale and coal Sand: fine and medium with coarse, angular to subrounded; quartz and rock fragments Fines: disseminated clay and silt, dark reddish brown (10 R 3/4) Clay, stony, firm to stiff, moderate reddish brown (10 R 4/6) to dark reddish brown (10 R 3/4), with fine gravel to cobble-sized clasts of angular to rounded yellow and red sandstones, andesite, coal, shale, dolerite, felsite, greywacke and siltstone; deposit is very sandy from 6.5 to 6.9m	1.1 4.3	6.2 10.5
Carboniferous (Calcareous Sandstone Measures)	Mudstone, greyish red (5 R 4/2), with pale grey calcareous nodules, cryoturbated at top, becoming less weathered with depth	1.2+	11.7

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
a	6	31	63	0.1- 1.2	5	4	12	12	27	32	8	
				1.2- 2.3	5	4	11	14	26	40	0	
				2.3- 3.3	6	6	19	14	23	32	0	
				3.3- 4.3	7	5	10	14	24	30	10	
				4.3- 5.1	6	3	11	17	31	22	10	
				Mean	6	4	13	14	26	32	5	
b	21	46	33	5.1- 6.2	21	21	16	9	19	14	0	
a&b	9	33	58	Mean	9	7	13	13	25	29	4	

Surface level +240m
(+787ft)
Water struck at +230m
250mm percussion
August 1982

Overburden 0.2m
Mineral 2.9m
Waste 1.0m
Mineral 3.7m
Waste 1.9m
Mineral 1.3m
Waste 1.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, medium brown, sandy, pebbly	0.2	0.2
Fluvioglacial sand and gravel	a 'Clayey' pebbly sand Gravel: fine and coarse with some cobbles, subangular to rounded; yellow, red and white sandstones, greywacke, siltstone, dolerite, vein-quartz, andesite and coal Sand: fine with medium and some coarse, subangular to subrounded; quartz with rock fragments, moderate brown (5 YR 3/4 to 5 YR 4/4) Fines: disseminated silt with seams towards base	2.9	3.1
	Silt, very sandy, laminated, moderate brown (5 YR 4/4)	1.0	4.1
	b 'Clayey' sandy gravel Gravel: fine and coarse with some cobbles, subangular to well rounded; greywacke, red, yellow and buff sandstones, indurated siltstone, quartz, chert, andesite and coal Sand: fine with medium and coarse, subangular to subrounded; quartz, with rock and coal fragments, moderate brown (5 YR 4/3 to 5 YR 4/4) Fines: seams of clay and silt at top, disseminated below 5.2m	3.7	7.8
Till	Clay, stony, moderate brown (5 YR 4/4) and stiff at top, greyish brown (5 YR 3/2) and very stiff below; contains angular to subrounded pebbles and boulders of greywacke, quartzite, dolerite, sandstone, quartz, indurated mudstone, coal and shale	1.9	9.7
Glacial sand and gravel	c Gravel Gravel: coarse, fine and cobble, subangular to rounded; red and yellow sandstones, greywacke, siltstone, andesite, dolerite and quartz Sand: fine, medium and coarse, angular to subrounded; quartz with rock fragments, moderate brown (5 YR 3/4) to greyish brown (5 YR 3/2) Fines: disseminated silt and clay	1.3	11.0
Till	Clay, stony, very stiff, dusky yellowish brown (10 YR 2/2), with angular to well rounded pebbles and boulders of yellow, red and white sandstones, dolerite, feldspar, greywacke, quartz, shale and coal	1.3+	12.3
Borehole terminated owing to slow progress			

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines			Gravel			
						$-\frac{1}{8}$	$+\frac{1}{8}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1-4	+4-16	+16-64	+64 mm
a	14	66	20	0.2- 1.7	9	12	24	16	23	16	0	
				1.7- 3.1	20	64	13	2	1	0	0	
				Mean	14	38	19	9	12	8	0	
b	17	57	26	4.1- 5.2	24	60	15	1	0	0	0	
				5.2- 6.2	9	11	25	21	24	10	0	
				6.2- 7.2	9	18	16	16	20	21	0	
				7.2- 7.8	29	15	11	11	17	11	6	
				Mean	17	28	17	12	15	10	1	
c	5	42	53	9.7-11.0	5	18	14	10	16	20	17	
a&b	16	60	24	Mean	16	31	18	11	14	9	1	
a-c	14	58	28	Mean	14	30	17	11	14	11	3	

Surface level +268m
 (+880ft)
 Water not struck
 250 and 200mm percussion
 July 1982

Overburden 0.3m
 Mineral 8.2m
 Waste 3.4m
 Bedrock 2.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	a 'Clayey' sandy gravel, tilloid from 1.3 to 1.7m Gravel: fine and coarse with some cobbles, angular to well rounded; red, yellow, brown and white sandstones, greywacke, indurated mudstone, dolerite, andesite, felsite, vein-quartz and ironstone Sand: fine with medium and some coarse, subangular to subrounded; quartz and rock fragments, moderate brown (5 YR 4/4) Fines: disseminated silt and clay but with clay binding deposit around 1.3m	6.4	6.7
Till	b 'Very clayey' sandy gravel Gravel: fine and coarse with some cobbles, angular to subrounded; yellow sandstone, quartz, chert, felsite, limestone and indurated mudstone and siltstone Sand: fine with medium and coarse, angular to subangular; moderate brown (5 YR 4/4), quartz and rock fragments Fines: disseminated clay with silt, binding the deposit Clay, stony, with 0.5m seams of gravel at 10.3m, firm to stiff, light brown (5 YR 5/4) to moderate brown (5 YR 4/4) but below 10.3m colour variable from greyish red (5 R 4/2) to dark grey (N 3); with angular to well rounded clasts of greywacke, red, yellow and white sandstones, indurated mudstone, dolerite, quartz and shale with ironstone and grey siltstone below 10.3m	1.8	8.5
Carboniferous (Limestone Coal Group)	Mudstone, dark grey (N 4), silty, with ironstone ribs, weathered and disturbed to 13.9m, firmer below Sandstone, coarse grained, calcareous, and limestone, sandy, with some chert	3.4	11.9
		2.0	13.9
		0.4+	14.3

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines			Sand		Gravel	
				from to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
a	18	50	32	0.3- 1.3	20	24	15	11	18	12	0
				1.3- 1.7	22	22	11	9	14	22	0
				1.7- 2.7	19	31	13	6	21	10	0
				2.7- 4.2	22	34	15	7	18	4	0
				4.2- 5.2	15	28	12	8	20	17	0
				5.2- 6.3	14	27	15	9	16	8	11
				6.3- 6.7	11	12	11	9	21	20	16
Mean	18	28	14	8	18	11	3				
b	29	37	34	6.7- 7.8	33	21	10	7	14	15	0
				7.8- 8.5	24	13	10	12	17	9	15
				Mean	29	18	10	9	15	13	6
a&b	21	46	33	Mean	21	25	13	8	18	12	3

NT 25 NE 141

2990 5785

Steelfoot Strip, Temple

Block E

Surface level +232m
 (+760ft)
 Water struck (perched) at
 +231m
 250mm percussion
 August 1982

Overburden 0.3m
 Mineral 1.9m
 Waste 4.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	'Very clayey' sandy gravel, with 0.1m seam of blue grey stony clay at 1.0m Gravel: fine and coarse with rare cobbles, subangular to rounded; cream and red sandstones, greywacke, basalt, ironstone, andesite, quartz, chert and coal below 1.1m Sand: fine with medium and coarse, subangular to rounded; quartz with rock, feldspar and coal fragments Fines: disseminated silt and clay, moderate brown (5 YR 4/4) to brownish black (5 YR 2/1)	1.9	2.2
	Clay, sandy and stony, pale brown (5 YR 5/2) with brownish grey gravel seam from 2.4 to 2.6m	0.4	2.6
Till	Clay, firm, sandy, pale brown (5 YR 5/2) with clasts of greywacke, sandstone, basalt and limestone	3.9+	6.5
	Borehole terminated owing to rock obstruction (limestone boulder)		

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
22	48	30	0.3- 1.1	16	16	9	9	21	29	0
			1.1- 2.2	26	31	20	8	10	5	0 §
			Mean	22	24	15	9	15	15	0

NT 25 SW 14

2065 5299

Cowdenburn, Newlands

Block G3

Surface level +286.3m
(+939.3ft)
Water struck at +277.4m
250mm percussion
September 1982

Overburden 0.2m
Mineral 8.4m
Bedrock 2.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark coloured, pebbly	0.2	0.2
Glacial sand and gravel	Gravel, 'clayey' to 4.2m Gravel: fine and coarse with some cobbles, angular to rounded; andesite, basalt, dolerite, limestone, yellow, green and red sandstones, greywacke, siltstone, porphyry, quartz and some coal debris Sand: fine to coarse, angular to rounded; quartz and rock fragments Fines: micaceous silt and clay binding this deposit locally; some inclusions of brown till, ochreous mud from rotted lavas and iron pan, dark yellowish orange (10 YR 6/6) to moderate reddish brown (10 R 4/6)	8.4	8.6
Carboniferous (Limestone Coal Group)	Sandstone, pale yellowish, friable, iron stained and with coaly laminations	1.1	9.7
	Mudstone, black, micaceous, hard and calcareous in parts, soft, fissile and with abundant plant debris in others, locally reddened	0.9+	10.6

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
9	45	46	0.2- 1.0	10	17	8	6	15	36	8
			1.0- 2.0	11	22	12	10	15	30	0
			2.0- 3.2	12	12	12	21	17	26	0
			3.2- 4.2	12	7	10	17	25	29	0
			4.2- 5.2	6	7	14	21	16	29	7
			5.2- 6.2	8	8	12	25	30	17	0
			6.2- 8.6	8	14	23	17	21	17	0
			Mean	9	13	15	17	20	24	2

Surface level +272.6m
 (+894.4ft)
 Water struck at +265.7m
 250mm percussion
 September 1982

Overburden 0.3m
 Mineral 4.2m
 Waste 0.4m
 Bedrock 2.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pale brown, sandy at base	0.3	0.3
Glacial sand and gravel	Gravel Gravel: fine and coarse with a few cobbles, angular to well rounded; yellow, red and brown sandstones, greenish muddy grit and greywacke, felsite, weathered andesite, some coal debris, reddened limestone and basalt Sand: fine to coarse, angular to well rounded; quartz and rock fragments Fines: brown silt and clay, binding gravel in parts	4.2	4.5
Till	Clay, stony, stiff, with pebbles of greywacke, sandstone and igneous rocks, dark reddish brown (10 R 3/3) to moderate brown (5 YR 3/4)	0.4	4.9
Carboniferous (Upper Limestone Group)	Clay, dark grey and black, hard, with fragments of white coal rich sandstone and mudstone Sandstone and mudstone, white friable sandstone, with micaceous, coaly laminations, deeply weathered but harder and iron stained downwards; with intercalations of black, micaceous mudstone and siltstone which is weathered to a sandy, black clay	0.4 1.8+	5.3 7.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
8	38	54	0.3-	1.4	9	8	13	16	30	24	0
			1.4-	2.4	10	13	11	9	29	28	0
			2.4-	3.4	4	11	9	13	27	36	0
			3.4-	4.5	8	12	15	19	26	20	0
			Mean		8	11	12	15	27	27	0

Surface level +247.8m
 (+813.0ft)
 Water not struck
 250 and 200mm percussion
 August 1982

Overburden 3.0m
 Mineral 1.0m
 Waste 2.8m
 Bedrock 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground, soil and fill	0.5	0.5
Head	Clay, laminated in parts, jointed, with leached and gleyed areas, soft and wet towards base, with small greywacke and black mudstone pebbles; dark yellowish brown (10 YR 4/2)	2.5	3.0
Glacial sand and gravel	'Clayey' gravel Gravel: fine and coarse with some cobbles, angular to rounded; grit and greywacke with some chert and volcanic rocks Sand: fine to coarse, angular to rounded; quartz and rock fragments Fines: brown silt and clay	1.0	4.0
Till	Clay, stony, hard, silty, medium dark grey (N 4), with pebbles of well rounded greywacke and angular sandstone to 5.0m, but softer, sandy, silty, moderate brown (5 YR 4/4) below, with more varied suite of clasts (chert, mudstones, volcanic rocks)	2.8	6.8
Ordovician	Greywacke, dark grey, hard	0.2+	7.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
15	31	54	3.0-	4.0	15	6	11	14	22	24	8

Surface level c+242m
(c+794ft)
Water not struck
Pit
August 1982

Overburden 0.2m
Mineral 1.0m
Waste 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, dark grey, peaty, stony	0.2	0.2
Glacial sand and gravel	Gravel Gravel: coarse and fine with cobbles, angular to rounded; greywacke with indurated siltstone Sand: coarse with medium and fine, angular to subangular; mainly greywacke fragments Fines: disseminated silt and clay, brownish grey	1.0	1.2
Till	Clay, stony, stiff, moderate brown, with fine gravel to cobble-sized angular clasts of greywacke with siltstone and quartz	0.2+	1.4

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
7	26	67	0.2- 1.2	7	3	8	15	29	38	0

Surface level c+247m
(c+809ft)
Water not struck
250 and 200mm percussion
August 1982

Overburden 0.3m
Mineral 4.4m
Waste 15.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, brown, sandy	0.3	0.3
Glacial sand and gravel	'Very clayey' sandy gravel Gravel: fine and coarse, subangular to subrounded; greywacke, sandstone and volcanic rocks Sand: fine with medium and coarse, subangular to subrounded Fines: disseminated silt and clay, locally binding the deposit but with seams of clayey sand up to 8cm thick below 2.3m, moderate brown (5 YR 4/4)	4.4	4.7
Till	Clay, stony, silty, sandy at top, firm then stiff, brownish grey (5 YR 4/1) to pale brown (5 YR 5/2) but moderate red (5 R 4/6) from 8.3 to 8.4m owing to fragmented red sandstone pebbles; subangular to well rounded clasts of brown and red sandstones, greywacke and lava with sporadic chert and vein-quartz	15.3+	20.0

Borehole terminated owing to excessive overburden

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand	Gravel					
			from	to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
23	42	35	0.3-	1.3	24	9	8	12	24	23	0
			1.3-	2.3	20	20	12	13	24	11	0
			2.3-	3.3	18	23	14	13	19	13	0
			3.3-	4.7	30	22	9	10	16	13	0
			Mean		23	19	11	12	20	15	0

NT 25 SW 19

2412 5375

Craigburn, Eddleston

Block D

Surface level c+262m
(c+860ft)
Water not struck
Pit
August 1982

Overburden 0.3m
Mineral 1.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, light brown	0.3	0.3
Glacial sand and gravel	Sandy gravel Gravel: fine and coarse, angular to rounded; greywacke, siltstone, yellow sandstone, andesite and vein-quartz Sand: medium with coarse and fine, angular to subrounded; quartz and rock fragments Fines: disseminated silt and clay, medium brown	1.8+	2.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand			Gravel		
			from	to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
5	48	47	0.3-	2.1	5	8	26	14	26	21	0

Surface level +258.8m
(+849.1ft)
Water seepage at c+252m
250mm percussion
September 1982

Overburden 0.3m
Mineral 2.0m
Waste 1.0m
Mineral 4.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, very sandy	0.3	0.3
Glacial sand and gravel	a 'Very clayey' pebbly sand Gravel: fine and coarse, chiefly angular; greywacke with some andesite and rare sandstone, dolerite, felsite and vein-quartz Sand: chiefly fine, rounded; quartz with rock fragments Fines: brown, micaceous silt	1.0	1.3
Glaciolacustrine deposits	b 'Very clayey' sand, with rare pebbles of greywacke, sandstone, andesite, dolerite, felsite and quartz Sand: fine, rounded; quartz and some rock and coal fragments Fines: brown, micaceous silt	2.0	3.3
	Silt, brown, micaceous, with much fine sand	1.0	4.3
	c 'Very clayey' sand, components as above	2.0	6.3
Glacial sand and gravel	d 'Clayey' sandy gravel Gravel: fine and coarse with a few cobbles, angular to rounded; greywacke and baked siltstone with some andesite, red, green and brown sandstones, basalt, andesite, felsite and vein-quartz Sand: fine with medium and coarse, subangular to rounded; quartz and rock fragments Fines: brown, disseminated silt	2.5+	8.8

Borehole abandoned on greywacke boulder or bedrock

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$\frac{1}{8}$	$\frac{1}{4}$ - $\frac{1}{2}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
a	26	55	19	0.3- 1.3	26	38	12	5	11	8	0	
b	30	69	1	1.3- 2.3	22	72	3	1	1	1	0	
				2.3- 3.3	38	60	1	0	0	1	0	
				Mean	30	67	2	**	**	1	0	
c	29	71	0	4.3- 5.3	22	77	1	0	0	0	0	
				5.3- 6.3	37	61	0	0	1	1	0	
				Mean	29	71	**	**	**	**	0	
d	18	41	41	6.3- 7.3	30	38	2	4	17	9	0	§
				7.3- 8.8	9	10	15	15	32	19	0	§
				Mean	18	21	10	10	26	15	0	
a&d	20	45	35	Mean	20	26	10	9	22	13	0	
b&c	30	69	1	Mean	30	68	1	**	**	1	0	
a-d	25	59	16	Mean	25	49	6	4	10	6	0	

Surface level +245.3m
 (+804.8ft)
 Water struck at +235.9m
 Composite log of sections
 and pit
 August 1982

Overburden 0.3m
 Mineral 10.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Gravel, but mainly sand from 0.3 to 1.7m and below 9.4m. Section obscured between 5.6 and 8.1m Gravel: coarse and fine with cobbles, subangular to well rounded; greywacke, grit and siltstone with red and yellow sandstones, andesitic lava and vein-quartz Sand: fine and medium with coarse, generally fining downwards, subangular; quartz with rock fragments Fines: disseminated silt and clay, and silt seams below 9.4m, medium brown to grey-brown	10.0+	10.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
7	46	47	0.3-	2.4	No grading data available						
			2.4-	3.3	2	5	33	23	21	16	0
			3.3-	4.3	1	1	9	16	31	39	3
			4.3-	8.1	No grading data available						
			8.1-	9.4	10	16	7	2	12	42	11
			9.4-	10.3	16	55	23	1	3	2	0
			Mean		7	19	17	10	17	26	4

NT 25 SE 1

2699 5447

Stell Plantation, Temple

Block D

Surface level c+280m
(c+918ft)
Water not struck
250 and 200mm percussion
August 1982

Overburden 0.2m
Mineral 6.6m
Waste 1.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, gravelly	0.2	0.2
Glacial sand and gravel	Gravel, 'clayey' in parts Gravel: coarse and fine with cobbles, subangular to rounded; chiefly greywacke with some white micaceous sandstone, chert, porphyry, indurated siltstone, andesite, dolerite and vein-quartz Sand: coarse with medium and fine, subangular to subrounded; quartz and rock fragments Fines: disseminated silt and silty clay seams, moderate brown (5 YR 4/4)	6.6	6.8
Till	Clay, stony, very hard, moderate brown (5 YR 4/4), with clasts of greywacke and sandstone	1.5+	8.3
Borehole abandoned on obstruction			

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
8	28	64	0.2- 1.2	8	8	6	8	16	20	34
			1.2- 2.2	12	8	14	15	27	24	0
			2.2- 3.2	7	6	15	20	24	16	12
			3.2- 4.2	3	2	5	6	11	34	39
			4.2- 5.2	7	3	6	13	34	37	0
			5.2- 6.8	11	6	7	15	24	30	7
			Mean	8	6	9	13	23	26	15

NT 25 SE 2

2699 5247

Tweeddaleburn, Temple

Block D

Surface level +288.4m
(+946.2ft)
Water not struck
250mm percussion
August 1982

Waste 2.5m
Bedrock nil

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Clay, stony, very sandy locally, soft, brown, with boulders of hard dark grey sandstone	2.2	2.5
Ordovician	Greywacke sandstone, dark grey, very hard, not penetrated	nil	2.5

Surface level +275m
 (+902ft)
 Water struck at +272m
 250mm percussion
 August 1982

Overburden 1.0m
 Mineral 0.9m
 Waste 0.2m
 Mineral 4.1m
 Waste 2.1m
 Bedrock 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey	0.3	0.3
Alluvium	Clay, sandy, with fine gravel sized clasts of sandstone and greywacke, moderate reddish brown (10 R 4/6)	0.7	1.0
Glacial sand and gravel	a 'Clayey' gravel Gravel: coarse and fine, subangular to subrounded; greywacke with trace of sandstone, siltstone and chert Sand: medium and coarse with fine, subangular; quartz and rock fragments Fines: disseminated silt and clay, moderate brown (5 YR 4/4)	0.9	1.9
	Clay, silty, laminated, firm, moderate reddish brown (10 R 4/6)	0.2	2.1
	b Gravel Gravel: fine and coarse, subangular to subrounded; greywacke with trace of andesite, sandstone, chert and vein-quartz Sand: medium and coarse with some fine, subangular to subrounded; quartz and rock fragments Fines: disseminated silt and clay, moderate brown (5 YR 4/4)	4.1	6.2
Till	Clay, sandy, stony, very stiff, moderate reddish brown (10 R 4/6) to greyish brown (5 YR 3/2) with clasts of greywacke and sandstone; below 7.4m moderate red (5 R 4/6) and with much decomposed sandstone and some coal	2.1	8.3
Carboniferous (Calciferous Sandstone Measures)	Siltstones, slightly micaceous, hard, unbedded, moderate red (5 R 4/6)	0.4+	8.7

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	-%	+ $\frac{1}{2}$ -%	+ $\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
8	32	60	1.0- 1.9	14	6	12	14	25	29	0
			2.1- 3.1	9	7	12	19	38	15	0
			3.1- 4.1	12	9	14	17	28	20	0 §
			4.1- 5.1	2	2	6	16	38	36	0 §
			5.1- 6.2	3	3	8	12	34	40	0 §
			Mean	8	5	11	16	32	28	0

Surface level c+272m
(c+893ft)
No record of water level
250 and 200mm percussion
August 1982

Overburden 0.2m
Mineral 4.1m
Waste 11.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, gravelly	0.2	0.2
Glacial sand and gravel	Gravel Gravel: coarse and fine with some cobbles, subangular to subrounded; chiefly durable greywacke with rare felsite, andesite, vein-quartz, chert, sandstone, rhyolite and siltstone Sand: medium with coarse and fine, subangular to subrounded, quartz and rock fragments Fines: disseminated silt and clay, moderate brown (5 YR 4/4)	4.1	4.3
Till	Clay, stony, stiff but becoming stiffer below 6m, moderate brown (5 YR 4/4); with clasts of fine and coarse gravel sized greywacke and sandstone	11.7+	16.0
Borehole abandoned owing to slow progress			

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
6	44	50	0.2- 1.2	4	3	7	12	22	45	7
			1.2- 2.2	9	18	19	13	18	23	0
			2.2- 3.2	5	4	9	17	24	29	12
			3.2- 4.3	7	15	44	15	13	6	0
			Mean	6	10	20	14	19	26	5

Surface level +279.66m
 (+917.52ft)
 Groundwater level +270.9m
 250 and 200mm percussion
 October 1982

Overburden 0.2m
 Mineral 4.8m
 Waste 5.3m
 Bedrock 1.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, grey, silty	0.2	0.2
Glacial sand and gravel	Gravel Gravel: coarse and fine with some cobbles, angular to rounded; greywacke with some sandstone, siltstone, shale, felsite, andesite, vein-quartz and chert Sand: coarse, medium and fine, angular to subrounded; quartz and rock fragments with feldspar Fines: disseminated silt and clay, light olive grey (5 Y 5/1) but oxidised to orange-brown near surface	4.8	5.0
Till	Clay, stony, firm to stiff, with subangular to subrounded clasts of greywacke with sandstone, greyish orange (10 YR 6/4)	3.0	8.0
	Sandy gravel Gravel: fine and coarse, subangular to rounded; greywacke, andesite, red sandstone and vein-quartz Sand: fine to coarse, subangular to subrounded; quartz and rock fragments Fines: disseminated silt and clay, moderate brown (10 YR 5/4)	0.9	8.9
	Clay, dusky yellowish brown (10 YR 3/2) to 9.6m, moderate yellowish brown (10 YR 5/4) below, slickensides in upper part, firm and silty, crudely bedded and with a few small clasts of coal, felsite, greywacke, sandstone, porphyry and vein-quartz; below 10m deposit is more sandy and contains more clasts	1.4	10.3
Carboniferous (Calciferous Sandstone Measures)	Sandstone, greyish red (10 R 5/2), fine grained, micaceous and faintly bedded, ripple marked below 10.9m, with 0.1m parting of soft, greyish red (5 R 4/2) finely bedded micaceous siltstone at 10.8m	1.0+	11.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
			from to	— $\frac{1}{16}$	+ $\frac{1}{16}$ — $\frac{1}{8}$	+ $\frac{1}{8}$ —1	+1—4	+4—16	+16—64	+64 mm
9	28	63	0.2- 2.0	13	6	8	10	22	23	18
			2.0- 3.0	9	6	9	14	24	32	6
			3.0- 4.0	7	6	10	17	30	27	3
			4.0- 5.0	6	5	11	14	27	31	6
			Mean	9	6	9	13	25	28	10

NT 25 SE 6

2968 5217

Moorfoot, Temple

Block D

Surface level +288.2m
(+945.5ft)
Water not struck
Pit
August 1982

Overburden 0.3m
Mineral 1.0m
Waste 0.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, medium grey, stony	0.3	0.3
Glacial sand and gravel	'Clayey' gravel Gravel: fine and coarse with some cobbles, angular to subrounded; predominantly greywacke Sand: coarse with medium and fine, angular to subangular; quartz with rock fragments Fines: disseminated silt and clay, medium brown	1.0	1.3
Till	Clay, stony, sandy, stiff, moderate brown, with closely packed, fine gravel to boulder sized, angular fragments of greywacke	0.4+	1.7

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
10	28	62	0.3- 1.3	10	4	9	15	32	30	0

NT 26 NW 110

2389 6545

Caerketton Hill, Lasswade

Block G₁

Surface level c+284m
(c+932ft)
Water seepage at c+282m
Pit
June 1982

Waste 3.0 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Glacial sand and gravel	'Clayey' gravel Gravel: coarse with fine and cobbles, subangular to well rounded, andesite with sandstone and grit Sand: fine to coarse, subangular, quartz and rock fragments Fines: silt and clay, disseminated, reddish brown	0.9	1.1
Till	Clay, stony, stiff, brownish red, containing angular to subangular erratics of andesite, sandstone and coal	1.9+	3.0

Surface level c+193m
(c+633ft)
Water struck at c+192m
Pit
June 1982

Overburden 0.2m
Mineral 1.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	Gravel, poorly sorted to 1.1m Gravel: fine with coarse, subangular to well rounded, sandstone, andesite, tuff, greywacke, felsite, vein-quartz, chert and dolerite Sand: medium, coarse and fine, quartz and rock fragments Fines: silt and clay, disseminated, reddish brown	1.3+	1.5

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	$\frac{1}{16}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
9	45	46	0.2- 1.5	9	11	19	15	28	18	0

Surface level +192.4m
 (+631.2ft)
 Water struck at +191.2m
 250mm percussion
 September 1982

Overburden 0.3m
 Mineral 3.2m
 Waste 4.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey, dark brown	0.3	0.3
Fluvioglacial sand and gravel	a 'Clayey' sandy gravel, poorly sorted to 1.0m Gravel: fine with coarse, subangular to well rounded, red, yellow and brown sandstones and andesite with felsite, vein-quartz, greywacke, coal and shale Sand: fine and medium with coarse, subangular to subrounded, quartz with coal and rock fragments Fines: silt with clay, disseminated and in some seams, moderate brown (5 YR 4/4)	1.7	2.0
	b 'Very clayey' sand Gravel: trace, fine, angular to subangular, as above in composition Sand: fine with rare medium and coarse, as above in shape and composition Fines: silt, disseminated and in seams, content increasing with depth	1.5	3.5
	Silt, laminated with seams of fine sand and reddish brown clay laminae, greyish brown (5 YR 4/2) to moderate brown (5 YR 4/4)	0.8	4.3
Till	Clay, stony, stiff, dark reddish brown (10 R 3/4), containing angular to subrounded erratics of sandstone, greywacke, chert, vein-quartz, andesite, coal, shale and felsite	3.3+	7.6
	Borehole terminated owing to an obstruction of andesite, possibly bedrock		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
a	11	53	36	0.3- 1.0	9	11	19	15	28	18	0	
				1.0- 2.0	13	28	22	8	18	11	0 §	
				Mean	11	22	20	11	22	14	0 §	
b	37	63	0	2.0- 3.5	37	58	4	1	**	0	0	
a&b	23	57	20	Mean	23	38	13	6	12	8	0	

Surface level +142m
(+467ft)
Water not struck
250mm percussion
September 1982

Overburden 0.3m
Mineral 4.0m
Waste 0.8m
Mineral 1.9m
Bedrock 0.4m†

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pebbly, dark grey-brown	0.3	0.3
Glacial sand and gravel	a 'Clayey' gravel, poorly sorted Gravel: coarse with fine and some cobbles, subangular to rounded, brown, yellow, white and red sandstones, greywacke, andesite, basalt, shale, coal, vein-quartz, dolerite, felsite, conglomerate and rare psammite Sand: coarse to fine, angular to subangular, quartz with rock fragments Fines: silt and clay, disseminated, moderate brown (5 YR 3/4)	4.0	4.3
Till	Clay, stony, stiff, greyish red (5 R 4/2) to dark reddish brown (10 R 3/4); containing angular to subrounded erratics of sandstone, greywacke, andesite, dolerite, coal, shale and vein-quartz	0.8	5.1
Glacial sand and gravel	b 'Clayey' sandy gravel, finely bedded Gravel: fine and coarse, subangular with subrounded to well rounded, yellow, brown and red sandstones, greywacke, andesite, felsite, coal, shale, vein-quartz, psammite, basalt, quartzite and chert Sand: fine and medium with coarse, subangular to subrounded, quartz with some rock fragments Fines: silt, disseminated, moderate brown (5 YR 4/4)	1.9	7.0
Lower Devonian	Andesitic lava, fresh, amygdaloidal	0.4+	7.4

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Gravel						
					from	to	mm	mm	mm	mm	mm
a	15	37	48	0.3- 1.3	20	11	14	11	16	28	0
				1.3- 2.3	14	12	9	14	17	24	10
				2.3- 3.3	13	12	12	14	20	25	4
				3.3- 4.3	12	13	14	13	20	28	0
				Mean	15	12	12	13	18	27	3
b	12	55	33	5.1- 6.1	14	29	25	9	13	10	0
				6.1- 7.0	10	16	16	12	24	22	0
				Mean	12	24	21	10	18	15	0
a&b	14	42	44	Mean	14	15	15	12	18	24	2

NT 26 NE 253

2554 6559

Damhead, Lasswade

Block G₁

Surface level +169m
(+556ft)
Water not struck
250mm percussion
August 1982

Waste 12.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, light brown	0.4	0.4
Till	Clay, silty, stony, firm, moderate brown, containing erratics of sandstone with felsite, vein-quartz and ironstone	1.4	1.8
	Clay, stony, stiff to very stiff, pale brown (5 YR 5/2) with a reddish hue to 7.4m becoming moderate brown (5 YR 3/4) to reddish brown; containing erratics of andesite, sandstone and basalt with felsite, vein-quartz, dolerite, shale, coal, quartzite and rhyolite	10.8+	12.6
Borehole terminated owing to slow progress			

NT 26 NE 254

2638 6761

Broomhills, City Parish of Edinburgh

Block G₁

Surface level +123m
(+404ft)
Groundwater level +123m
250mm percussion
September 1982

Waste 8.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, peaty	0.3	0.3
Alluvium	Clay, silty, homogeneous, containing some mica, moderate brown (5 YR 4/4) with iron staining	0.5	0.8
	Clay, homogeneous, light bluish grey (5 B 5/1) with some iron staining	0.5	1.3
	Silt, clayey, laminated, comprising moderate brown (5 YR 3/4) silt with brownish grey (5 YR 4/1) clay laminae	0.7	2.0
Till	Clay, sandy, stony, stiff, moderate brown (5 YR 3/4) with a greyish red hue, containing angular to subrounded erratics of sandstone, greywacke, andesite, felsite, vein-quartz, coal and shale	6.7+	8.7
Borehole terminated owing to slow progress			

Surface level +154m
 (+506ft)
 Water struck at +137m
 250 and 200mm percussion
 September 1982

Overburden 2.7m
 Mineral 23.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, grey-brown	0.7	0.7
Till	Clay, sandy, stony, firm becoming stiff, moderate brown (5 YR 3/4) with a reddish hue; containing angular to rounded erratics of sandstone, andesite, felsite, greywacke, coal, shale and vein-quartz	2.0	2.7
Fluvioglacial sand and gravel	<p>a Pebbly sand</p> <p>Gravel: fine with coarse, subrounded to well rounded, yellow, brown and white sandstones, greywacke, siltstone, chert, shale, quartzite, andesite, dolerite, felsite and vein-quartz; mainly durable</p> <p>Sand: medium and fine with coarse, subangular to subrounded, quartz with rock and coal fragments</p> <p>Fines: silt, disseminated and in seams moderate brown (5 YR 3/4) to moderate yellowish brown (10 YR 5/4)</p>	4.1	6.8
	<p>b Gravel</p> <p>Gravel: coarse and fine with some cobbles, as above in shape and composition</p> <p>Sand: medium and coarse with fine, subangular, quartz with rock fragments</p> <p>Fines: silt, disseminated, moderate brown (5 YR 3/4)</p>	2.6	9.4
	<p>c 'Clayey' sand</p> <p>Gravel: fine and coarse, rounded, yellow sandstone, felsite, vein-quartz, coal, shale, andesite and greywacke</p> <p>Sand: fine with medium and rare coarse, subrounded, quartz with some coal and rock fragments</p> <p>Fines: silt, disseminated and in thin seams, moderate brown (5 YR 4/4)</p>	1.8	11.2
	<p>d Gravel</p> <p>Gravel: coarse with fine and rare cobbles, subangular to well rounded, red, yellow, brown and white sandstones, andesite, dolerite, greywacke, vein-quartz, felsite and shale</p> <p>Sand: medium with coarse and some fine, subangular to subrounded, quartz with rock fragments</p> <p>Fines: silt, disseminated and in thin seams, moderate brown (5 YR 4/4)</p>	3.1	14.3
	<p>e 'Clayey' sandy gravel</p> <p>Gravel: fine and coarse with rare cobbles, subangular to well rounded, yellow, brown and red sandstones, andesite, felsite, greywacke, coal, shale and vein-quartz</p> <p>Sand: fine with medium and coarse, subangular to subrounded, quartz with coal and rock fragments</p> <p>Fines: silt and clay, disseminated and in thin seams, moderate brown (5 YR 3/4)</p>	3.0	17.3

LOG

Geological classification	Lithology	Thickness m	Depth m
	f 'Clayey' sand Gravel: rare, fine and coarse, subangular to rounded, coal, felsite, sandstone, andesite and shale Sand: fine with medium and some coarse, angular to subrounded, quartz with feldspar, coal and rock fragments Fines: silt, disseminated and in seams, moderate brown (5 YR 3/4)	8.7+	26.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines		Sand			Gravel		
					from	to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64
a	8	71	21	2.7- 3.4	16	26	19	9	17	13	0	
				3.4- 4.2	7	54	33	3	3	0	0	
				4.2- 5.8	5	10	43	21	17	4	0	
				5.8- 6.8	8	34	24	7	20	7	0	
				Mean	8	27	32	12	15	6	0	
b	7	38	55	6.8- 7.8	6	6	19	16	28	25	0	
				7.8- 9.4	7	7	18	11	25	32	0	
				Mean	7	7	18	13	26	29	0	
c	19	77	4	9.4-10.4	14	43	37	3	3	0	0	
				10.4-11.2	24	60	8	1	2	5	0	
				Mean	19	51	24	2	2	2	0	
d	7	37	56	11.2-12.3	6	5	21	11	21	36	0	
				12.3-13.3	6	5	25	13	28	23	0	
				13.3-14.3	8	7	14	9	22	40	0	
				Mean	7	6	20	11	23	33	0	
e	16	53	31	14.3-15.3	15	6	22	17	20	12	8	
				15.3-16.1	16	13	14	11	24	22	0	
				16.1-17.3	17	55	8	6	10	4	0	
				Mean	16	28	14	11	17	11	3	
f	13	85	2	17.3-18.5	17	70	12	1	0	0	0	\$
				18.5-19.7	10	68	22	0	0	0	0	\$
				19.7-21.7	22	66	10	2	0	0	0	\$
				21.7-23.9	12	29	43	10	3	3	0	\$
				23.9-26.0	7	44	39	9	1	0	0	\$
				Mean	13	53	27	5	1	1	0	
a&b	8	58	34	Mean	8	19	27	12	19	15	0	
b&d	7	37	56	Mean	7	6	19	12	25	31	0	
a&b&d&e	9	52	39	Mean	9	18	22	12	20	18	1	
a&b	11	54	35	Mean	11	22	21	11	18	16	1	
a-f	12	66	22	Mean	12	33	24	9	11	11	**	

Surface level +156m
 (+511ft)
 Groundwater level +150m
 250mm percussion
 August 1982

Overburden 1.8m
 Mineral 1.4m
 Waste 2.0m
 Bedrock 0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.9	0.9
Till	Clay, stony, firm becoming stiff, mottled moderate reddish brown (10 R 4/6) to moderate brown (5 YR 4/4); containing angular to rounded erratics of sandstone, shale, coal, greywacke, andesite and felsite	0.9	1.8
Fluvioglacial sand and gravel	'Clayey' pebbly sand Gravel: fine with coarse, subangular to well rounded, yellow and red sandstones, greywacke, siltstone, shale, coal, felsite, dolerite and vein-quartz Sand: medium with fine and some coarse, subangular to subrounded, quartz with rock fragments Fines: silt, disseminated and in thin seams, moderate brown (5 YR 4/4)	1.4	3.2
	Silt, sandy, laminated, moderate brown (5 YR 3/4)	0.7	3.9
Till	Clay, stony, hard and greyish brown (5 YR 3/2) to 4.1m becoming very stiff and very dusky red (10 R 2/2). Containing erratics of sandstone, greywacke, siltstone, shale, mudstone, coal, andesite and felsite	1.3	5.2
Carboniferous (Upper Oil Shale Group)	Mudstone, silty, medium grey (N 5) to medium bluish grey (5 B 5/1)	0.8+	6.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand	Gravel					
			from	to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
10	84	6	1.8-	3.2	10	19	57	8	4	2	0

Surface level +137m
(+448ft)
Groundwater levels +130m and
+121m
250 and 200mm percussion
September 1982

Overburden 5.0m
Mineral 2.0m
Waste 1.2m
Mineral 1.2m
Waste 6.7m
Bedrock 0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, silty	0.3	0.3
Head	Silt, clayey, sandy, containing rare pebbles, moderately soft, crudely bedded in part, mottled light brown (5 YR 5/6) to moderate brown (5 YR 4/4) with thin black coal rich laminae	1.7	2.0
Glacial sand and gravel	Clay, silty, laminated, firm, brownish grey (5 YR 4/1), containing subangular to rounded pebbles of sandstone, siltstone, shale, coal and andesite from 2.2 to 2.5m and seams of fine sand	1.8	3.8
	Clay, pebbly, sandy, dark yellowish brown (10 YR 4/2), comprising seams of silt and clay, fine sand and coarse to fine gravel, composed of sandstone, siltstone, basalt, andesite, felsite, coal, dolerite, ironstone, chert and vein-quartz	1.2	5.0
	a 'Clayey' sandy gravel Gravel: coarse with fine and some cobbles, subangular to rounded, sandstone, andesite, limestone, conglomerate, siltstone, felsite, dolerite, coal, chert and vein-quartz Sand: fine and medium with coarse, subangular to subrounded, quartz with feldspar, coal and rock fragments Fines: silt and clay, disseminated and in seams, moderate yellowish brown (10 YR 5/4) to dark yellowish brown (10 YR 4/2)	2.0	7.0
	Silt, sandy, laminated, containing a pebbly seam, light brownish grey (5 YR 5/1)	1.2	8.2
	b 'Very clayey' sand Gravel: rare, fine, angular to subrounded, sandstone with andesite, chert, greywacke, coal and vein-quartz Sand: fine with some medium and rare coarse, subangular to subrounded, quartz with feldspar, coal and rock fragments Fines: silt and clay, disseminated and in seams, light brownish grey (5 YR 5/1)	1.2	9.4
	Silt, clayey, laminated, containing seams of fine sand, dark grey (N 3) to brownish grey (5 YR 4/1)	0.4	9.8
Till	Clay, stony, silty, stiff, brownish grey (5 YR 3/1) with a reddish hue from 14.5m, containing erratics of sandstone, limestone, shale and coal with andesite, felsite and quartzite	6.3	16.1
Carboniferous (Lower Oil Shale Group)	Sandstone, fine grained, thinly bedded, containing carbonaceous and micaceous laminae, weathered, pale yellowish brown (10 YR 6/2) becoming darker with depth	0.8+	16.9

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$\frac{1}{8}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
a	18	49	33	5.0- 5.8	29	33	26	6	4	2	0	
				5.8- 7.0	10	12	17	11	15	28	7	§
				Mean	18	20	20	9	11	18	4	
b	28	71	1	8.2- 9.4	28	54	15	2	1	0	0	§
a&b	22	57	21	Mean	22	32	19	6	7	11	3	

NT 26 NE 258

2777 6637

Ashgrove, Lasswade

Block B

Surface level +134.8m
(+442.3ft)
Water seepage at +132.4m
Pit
June 1982

Overburden 1.1m
Mineral 1.1m
Waste 0.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, silty, grey	0.3	0.3
Alluvium	Clay, silty, pebbly, soft, orange-brown, containing some weathered pebbles	0.7	1.0
	Clay, pebbly, stiff, medium grey, containing angular to subrounded pebbles of andesite, sandstone, coal and shale	0.1	1.1
	'Clayey' sandy gravel, poorly sorted Gravel: coarse and fine, angular to subrounded, andesite with sandstone, shale and coal Sand: fine with medium and some coarse, angular to subangular, rock fragments and quartz Fines: silt and clay, disseminated, medium grey	1.1	2.2
Till	Clay, stony, stiff, medium grey, containing angular to subangular erratics of andesite, sandstone, weathered shale and coal	0.2+	2.4

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$\frac{1}{8}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
	16	52	32	1.1- 2.2	16	29	16	7	14	18	0	

Surface level +109m
 (+356ft)
 Water not struck
 250mm percussion
 August 1982

Overburden 1.8m
 Mineral 1.4m
 Waste 0.3m
 Bedrock 0.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Till	Clay, sandy, silty, stony, firm to moderately stiff, mottled pale brown (5 YR 5/2) to light brown (5 YR 5/6), containing erratics of sandstone with shale, dolerite, coal, siltstone, andesite and quartzite	1.3	1.8
Fluvioglacial sand and gravel	'Clayey' pebbly sand Gravel: fine with coarse, angular to rounded, sandstone with coal, siltstone, vein-quartz, andesite, felsite, greywacke and shale Sand: medium with coarse and fine, subangular to subrounded, quartz with rock and coal fragments Fines: silt, disseminated, dark yellowish brown (10 YR 4/2)	1.4	3.2
Till	Clay, stony, stiff, mottled moderate brown (5 YR 4/4 to 5 YR 3/4), containing erratics of sandstone, ironstone and dolerite	0.3	3.5
Carboniferous (Upper Limestone Group)	Sandstone, fine grained, weathered, very pale orange (10 YR 8/4)	0.9+	4.4

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand	Gravel					
			from	to	$\frac{1}{8}$	$\frac{1}{4}$ - $\frac{1}{2}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
19	65	16	1.8-	3.2	19	12	35	18	11	5	0

NT 26 NE 260

2910 6669

Wester Melville, Lasswade

Block G₁

Surface level +127m
(+416ft)
Water not struck
250mm percussion
September 1982

Waste 4.9m
Bedrock 0.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, brown	0.7	0.7
Till	Clay, stony, stiff, moderate brown (5 YR 4/4) to dark yellowish brown (10 YR 4/2), containing angular to well rounded erratics of sandstone, quartzite, andesite, dolerite, vein-quartz, porphyry and conglomerate. Becoming dusky brown (5 YR 2/2) to brownish grey (5 YR 4/1), moderately stiff and including mudstone and felsite erratics below 3.5m	4.2	4.9
Carboniferous (Upper Limestone Group)	Seatrock, mudstone, dark grey to black, and fine grained white sandstone. Deposits micaceous, calcareous and containing root casts	0.5+	5.4

NT 26 NE 261

2936 6602

Wadingburn, Lasswade

Block B

Surface level +118m
(+386ft)
Water not struck
250 and 200mm percussion
September 1982

Overburden 0.4m
Mineral 1.3m
Waste 3.0m
Mineral 13.6m
Waste 3.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy	0.4	0.4
Fluvioglacial sand and gravel	a 'Clayey' sandy gravel Gravel: fine with coarse, subangular to well rounded, sandstone, felsite, quartzite, vein-quartz, andesite, dolerite, chert and coal Sand: fine with medium and some coarse, subangular to subrounded, quartz with feldspar and rock fragments Fines: silt and clay, disseminated	1.3	1.7
Till	Clay, stony, sandy, firm to stiff, pale brown (5 YR 5/2) to moderate brown (5 YR 4/4) with a reddish hue, containing angular to rounded erratics of sandstone, coal, shale, andesite, felsite and dolerite	3.0	4.7
Glaciolacustrine deposits	b 'Clayey' sand Gravel: trace of fine, coal Sand: fine with some medium and trace of coarse, subrounded, quartz with coal fragments Fines: silt with clay, in laminated seams and disseminated, light brown (5 YR 5/6 to 5 YR 6/4)	13.6	18.3
	Silt, laminated, containing thin clay laminae and some coal debris, dusky brown (5 YR 2/2), to greyish brown (5 YR 3/2)	1.2	19.5
Till	Clay, stony, very stiff, dusky yellowish brown (10 YR 2/2), containing angular to subrounded erratics of sandstone, greywacke, andesite, felsite, coal, shale, vein-quartz, and mudstone	0.7	20.2

LOG

Geological classification	Lithology	Thickness m	Depth m
	Clay, silty, stony, firm, similar in colour and erratic content to above deposit but containing some interbedded laminated silt	0.4	20.6
	Clay, stony, stiff, greyish brown (5 YR 3/2) with a reddish hue, containing angular to rounded erratics of sandstone, andesite, felsite, coal, shale and vein-quartz	0.7+	21.3
Borehole terminated owing to slow progress			

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages								
	Fines	Sand	Gravel		from	to	Fines		Sand		Gravel		
							$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
a	13	65	22	0.4-	1.7	13	32	22	11	17	5	0	
b	18	82	0	4.7-	5.7	29	67	3	1	0	0	0	
				5.7-	7.0	18	76	3	1	2	0	0	0
				7.0-	8.0	10	89	1	0	0	0	0	0
				8.0-	9.0	14	82	4	0	0	0	0	0
				9.0-	10.0	13	82	5	0	0	0	0	0
				10.0-	11.0	22	76	2	0	0	0	0	0
				11.0-	12.0	18	78	4	0	0	0	0	0
				12.0-	13.0	16	77	7	0	0	0	0	0
				13.0-	14.0	14	61	25	0	0	0	0	0
				14.0-	15.0	11	68	21	0	0	0	0	0
				15.0-	17.0	19	66	15	0	0	0	0	0
	17.0-	18.3	26	69	5	0	0	0	0	0			
	Mean		18	74	8	**	**	0	0				
a&b	17	81	2	Mean	17	71	9	1	2	**	0		

NT 26 NE 262

2991 6553

Polton House, Lasswade

Block B

Surface level +65.5m
(+214.9ft)
Water not struck
Pit
June 1982

Overburden 0.8m
Mineral 1.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.8	0.8
Alluvium	Gravel, finely bedded Gravel: coarse, fine and cobble, subrounded to well rounded, red and white sandstones, andesite, basalt, felsite, quartzite and vein-quartz Sand: medium and coarse with fine, subangular to subrounded, quartz with rock fragments Fines: silt, disseminated, medium brown	1.3+	2.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
1	34	65	0.8- 2.1	1	7	14	13	18	23	24

NT 26 NE 263

2974 6683

Melville sand pit, Lasswade

Block B

Surface level +109m
(+358ft)
Water not struck
Section, sampled by hand
December 1982

Overburden 0.3m
Mineral 12.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	a Gravel Gravel: coarse and fine with rare cobbles, subangular to well rounded, sandstone, coal, shale, felsite, andesite and vein-quartz Sand: medium with coarse and rare fine, angular to subangular, quartz with rock fragments Fines: silt, disseminated, moderate brown	2.0	2.3
	b Sand, finely bedded Sand: fine with medium and trace of coarse, subangular to subrounded, quartz with some rock and coal fragments Fines: silt, disseminated and in thin seams, moderate brown	10.0+	12.3

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					from to	$\frac{1}{16}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{8}$ -1	+1-4	+4-16	+16-64
a	1	43	56	0.3- 2.3	1	3	26	14	25	31	0
b	7	93	0	2.3-12.3	7	54	39	**	0	0	0
a&b	6	85	9	Mean	6	45	37	3	4	5	0

NT 26 SW 82

2096 6086

Grain Burn, Penicuik

Block C

Surface level c+290m
(c+951ft)
Water seepage at c+289m
Pit
June 1982

Overburden 0.2m
Mineral 1.8m
Waste 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Gravel Gravel: coarse, fine and cobble, angular to rounded, andesite with some sandstone Sand: coarse to fine, angular to subangular, rock fragments and quartz Fines: silt, disseminated, medium brown	1.8	2.0
Till	Clay, stony, stiff, dark greyish brown, containing angular to subrounded erratics of andesite, sandstone, greywacke and coal	0.1+	2.1

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
					from to	$\frac{1}{16}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{8}$ -1	+1-4	+4-16	+16-64
4	33	63	0.2- 1.2	2	4	9	15	20	26	24	
			1.2- 2.0	6	13	14	13	21	19	14	§
			Mean	4	8	11	14	20	23	20	

Surface level +262.5m
(+861.2ft)
Groundwater level +252.8m
250mm percussion
August 1982

Overburden 2.2m
Mineral 2.7m
Waste 2.4m
Mineral 1.9m
Waste 5.2m
Bedrock 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, silty, sandy, stony, firm, mottled moderate reddish brown (10 R 4/6)	1.9	2.2
Fluvioglacial sand and gravel	a 'Very clayey' sand Gravel: rare fine with trace of coarse, mainly angular, sandstone and andesite with porphyry vein-quartz and shale Sand: fine with rare medium and coarse, subangular to rounded, quartz with some coal fragments Fines: silt, disseminated and in seams, light brown (5 YR 5/6)	2.7	4.9
	Silt, laminated, with fine sand seams and rare pebbles, colour laminated, moderate brown (5 YR 4/4) and brownish grey (5 YR 4/1)	2.4	7.3
	b 'Clayey' pebbly sand Gravel: coarse and fine with rare cobbles, angular to rounded, andesite, sandstone, greywacke, vein-quartz, basalt and rare felsite Sand: fine with some medium and rare coarse, angular to subrounded, quartz with mica and some rock fragments, with coal debris concentrated in seams Fines: silt, disseminated and in seams, brownish grey (5 YR 4/1)	1.9	9.2
Till	Clay, stony, sandy, stiff, greyish brown (5 YR 3/2) to 10.2m becoming greyish red (10 R 4/2), containing angular to well rounded erratics of sandstone, andesite, basalt, greywacke, vein-quartz, quartzite, siltstone, coal and shale	3.3	12.5
?Glaciolacustrine deposits	Silt, containing rare laminae of fine sand and rare pebbles, moderate brown (5 YR 3/3)	0.5	13.0
Till	Clay, stony, sandy, stiff, greyish red (10 R 4/2), containing erratics of red sandstone with some grey sandstone, andesite, basalt, limestone, dolerite and felsite	1.4	14.4
Carboniferous (Upper Oil Shale Group)	Sandstone, fine grained, massive, fresh, greyish red (5 R 4/2) but locally mottled with greyish pink (5 R 7/2)	0.3+	14.7

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
						from	to	- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{8}$	$+\frac{1}{8}$ -1	+1-4
a	26	73	1	2.2- 3.9	33	57	6	2	2	0	0
				3.9- 4.9	15	84	1	0	0	0	0
				Mean	26	68	4	1	1	**	0
b	15	70	15	7.3- 8.3	14	65	9	2	4	6	0 §
				8.3- 8.8	16	58	9	3	7	7	0 §
				8.8- 9.2	15	43	14	4	9	8	7 §
				Mean	15	57	10	3	6	7	2
a&b	21	72	7	Mean	21	64	6	2	3	3	1

NT 26 SW 84

2104 6006

Silverburn, Penicuik

Block C

Surface level +275.9m
(+905.2ft)
Groundwater level +256.7m
250 and 200mm percussion
August 1982

Overburden 0.3m
Mineral 16.9m
Waste 7.8m†

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy with pebbles, medium to dark brown	0.3	0.3
Glacial sand and gravel	a 'Clayey' pebbly sand Gravel: fine with coarse, subangular to well rounded, yellow, cream and red sandstones, greywacke, shale, andesite, felsite, vein-quartz, coal and chert Sand: medium and fine with coarse, subangular to subrounded, quartz with some coal, rock fragments and feldspar Fines: silt, disseminated and in seams from 2.9m, moderate brown (5 YR 3/4)	5.1	5.4
	b 'Clayey' sand Gravel: trace of fine Sand: fine with medium and rare coarse, subangular to subrounded, quartz with coal, some rock fragments and feldspar Fines: silt, disseminated and in seams, moderate brown (5 YR 3/4) to moderate yellowish brown (10 YR 5/4) and greyish brown (5 YR 4/2) below 10.6m	6.7	12.1
	c 'Clayey' gravel Gravel: fine with coarse and rare cobbles, mainly subangular to subrounded, sandstone, greywacke, basalt, dolerite, limestone and rare felsite; clasts mainly durable Sand: coarse and medium with fine, mainly subangular, quartz and rock fragments Fines: silt, disseminated, greyish yellowish brown (10 YR 5/2) to moderate yellowish brown (10 YR 5/4)	2.9	15.0

LOG

Geological classification	Lithology	Thickness m	Depth m
	d 'Clayey' pebbly sand Gravel: fine and coarse, angular to rounded, sandstone, greywacke, coal, andesite, chert, felsite and shale Sand: medium with fine and coarse, subangular to subrounded, quartz and rock fragments with feldspar and seams of coal debris Fines: silt and clay, mainly in seams, greyish yellowish brown (10 YR 5/2)	2.2	17.2
Glaciolacustrine deposits	Silt, laminated, containing seams of fine sand and rare pebbles, moderate yellowish brown (10 YR 5/4) and light brownish grey (5 YR 5/1)	5.0	22.2
Till	Clay, stony, sandy, silty, soft to 22.9m becoming stiff, moderate yellowish brown (10 YR 5/4) to 22.5m becoming dusky yellowish brown (10 YR 3/2), containing angular to rounded erratics of andesite and sandstone with limestone, coal, felsite, vein-quartz, ironstone and dolerite	2.8+	25.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
a	10	71	19	0.3- 1.4	1	5	19	44	25	6	0	
				1.4- 2.3	13	47	28	8	3	1	0	
				2.3- 3.4	13	27	27	10	17	6	0	
				3.4- 4.4	12	34	35	8	10	1	0	
				4.4- 5.4	13	24	36	7	11	9	0	
				Mean	10	27	28	16	14	5	0	
b	19	81	0	5.4- 6.4	10	44	42	4	0	0	0	
				6.4- 7.4	12	42	45	1	0	0	0	
				7.4- 8.4	15	57	26	1	1	0	0	
				8.4- 9.4	17	64	19	0	0	0	0	
				9.4-10.6	26	62	12	0	0	0	0	
				10.6-12.1	26	46	27	1	0	0	0	
				Mean	19	52	28	1	**	0	0	
c	11	40	49	12.1-13.1	12	8	18	22	31	9	0	
				13.1-14.1	7	7	11	11	24	33	7	
				14.1-15.0	13	10	17	17	27	16	0	
				Mean	11	8	15	17	28	19	2	
d	16	78	6	15.0-16.0	19	27	44	9	1	0	0	
				16.0-17.2	13	17	37	22	5	6	0	
				Mean	16	22	40	16	3	3	0	
a&c	10	60	30	Mean	10	20	24	16	19	10	1	
b&d	18	80	2	Mean	18	44	31	5	1	1	0	
a-d	14	72	14	Mean	14	34	28	10	9	5	**	

Surface level c+271m
(c+889ft)
Water struck at c+269m
Pit
June 1982

Overburden 0.9m
Mineral 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Head	Clay, silty, sandy, pebbly, tenacious, mottled brownish red, containing angular to rounded clasts of andesite with some sandstone and coal	0.7	0.9
Glacial sand and gravel	'Very clayey' sand Gravel: fine with coarse, rounded, predominantly andesite with some coal Sand: fine with some medium and rare coarse, subangular to subrounded, quartz with coal and rock fragments Fines: silt, disseminated, medium brown	1.2+	2.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
32	65	3	0.9- 2.1	32	55	8	2	2	1	0

NT 26 SW 86

2296 6133

Cuiken, Glencorse

Block C

Surface level c+210m
(c+688ft)
Water struck (artesian) at
c+206m
250mm percussion
August 1982

Overburden 4.0m
Mineral 1.6m
Waste 1.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Till	Clay, sandy, stony, soft and moderate brown (5 YR 4/4) to 1.0m becoming firm and dusky brown (5 YR 2/2) to brownish black (5 YR 2/1). Containing erratics of sandstone, andesite, mudstone and coal	3.9	4.0
Glacial sand and gravel	Gravel Gravel: cobble and coarse with fine, subangular to rounded, sandstone, tuff, andesite, basalt, felsite, quartz, dolerite, psammite, greywacke, coal and rare granite Sand: fine and medium with some coarse, angular to subrounded, quartz and rock fragments Fines: clay, moderate brown	1.6	5.6
Till	Clay, stony, very stiff, brownish black (5 YR 2/1) to dusky yellowish brown (10 YR 2/2), sandy in places, containing erratics of andesite, sandstone, greywacke and quartzite with felsite, basalt, vein-quartz and mudstone	1.5+	7.1
Borehole terminated owing to artesian water flow			

Grading

Mean for Deposit percentages			Depth below surface (m)		percentages							
Fines	Sand	Gravel	from	to	Fines	Sand	Gravel					
					$\frac{1}{16}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm	
7	36	57	4.0-	5.0	7	10	12	4	10	27	30	§
			5.0-	5.6	8	22	19	9	12	11	19	§
			Mean		7	15	15	6	11	21	25	

NT 26 SW 87

2342 6370

Crosshouse, Glencorse

Block G₁

Surface level c+229m
(c+751ft)
Water seepage at c+227m
Pit
June 1982

Waste 1.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, stony, stiff, mottled brownish red, containing angular to rounded erratics of andesite with sandstone, greywacke, coal and felsite	1.7+	1.9

NT 26 SW 88

2377 6289

Glencorse Mains, Glencorse

Block G₁

Surface level c+186m
(c+610ft)
Water not struck
Pit
June 1982

Waste 1.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, stony, stiff, mottled yellow-orange-red-brown, containing angular to rounded erratics of sandstone, andesite and basalt with some greywacke, quartzite and ironstone	1.6+	1.8

NT 26 SW 89

2410 6455

Fulford, Glencorse

Block G₁

Surface level +202.9m
(+665.7ft)
Water not struck
Pit
June 1982

Overburden 0.3m
Mineral 2.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.3	0.3
Alluvium	Gravel Gravel: coarse and fine with cobbles, subrounded to well rounded, andesite with red and white sandstones, basalt, tuff, felsite, greywacke, granite and vein-quartz Sand: coarse to fine, subangular to subrounded, quartz with rock fragments, medium brown Fines: silt, disseminated with a mottled greyish orange clayey silt seam from 1.7 to 1.8m	2.0+	2.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
6	37	57	0.3-	2.3	6	9	14	14	19	24	14

NT 26 SW 90

2409 6454

Fulford, Glencorse

Block G₁

Surface level +202.9m
(+665.7ft)
Water struck at +198.2 and
+195.2m
250mm percussion
September 1982

Overburden 0.4m
Mineral 4.3m
Waste 3.0m
Bedrock 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey, medium brown	0.4	0.4
Alluvium	'Clayey' sandy gravel Gravel: fine with coarse and rare cobbles, angular to well rounded, andesite with yellow and brown sandstones, shale, coal, greywacke, felsite, siltstone, quartzite, dolerite and vein-quartz Sand: medium, fine and coarse, angular to subangular, quartz and rock fragments Fines: silt and clay, disseminated, moderate brown (5 YR 3/4 to 5 YR 4/4)	4.3	4.7
Till	Clay, sandy, stony, firm becoming stiff, dark reddish brown (10 R 3/4), containing erratics of andesite, felsite, greywacke, sandstone, siltstone, shale, quartzite and vein-quartz	3.0	7.7
Lower Devonian	Andesite, fresh, dark grey with a reddish hue, containing green amygdales	0.3+	8.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{8}$	$+\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
12	44	44	0.4-	2.0	20	12	15	11	22	20	0
			2.0-	3.2	8	17	24	14	24	13	0
			3.2-	4.2	6	15	19	13	28	19	0
			4.2-	4.7	5	9	14	10	27	35	0
			Mean		12	14	18	12	25	19	0

NT 26 SW 91

2408 6399

Easter Howgate, Glencorse

Block G₁

Surface level c+206m
(c+676ft)
Water seepage at c+204m
Pit
June 1982

Waste 2.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, silty, stony, soft to tenacious, orange-brown, containing angular erratics up to 15mm across	0.6	0.9
	Clay, stony, tenacious to stiff, brownish grey, containing angular erratics of andesite and sandstone	1.1+	2.0

NT 26 SW 92

2461 6394

Woodside Cottages, Glencorse

Block G₁

Surface level c+189m
(c+620ft)
Water not struck
Pit
June 1982

Waste 0.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey loam	0.3	0.3
Till	Clay, stony, tenacious to stiff, mottled brown, containing subangular to subrounded erratics of sandstone, mudstone and coal	0.6+	0.9

NT 26 SW 93

2428 6366

Bush House, Glencorse

Block G₁

Surface level c+192m
(c+630ft)
Water seepage at c+190m
Pit
May 1982

Overburden 0.8m
Mineral 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Silt, sandy, mottled pinkish brown	0.5	0.8
	'Clayey' sand Sand: fine with some medium, subrounded, quartz with coal fragments Fines: silt, disseminated and in some thin seams, moderate brown	1.2+	2.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
14	86	0	0.8-	2.0	14	74	12	0	0	0	0

Surface level +190m
 (+623ft)
 Water struck at +181m
 250 and 200mm percussion
 August 1982

Overburden 0.2m
 Mineral 12.3m
 Waste 8.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, gravelly, brown	0.2	0.2
Fluvioglacial sand and gravel	a Sandy gravel Gravel: coarse and fine with rare cobbles, subangular to well rounded, sandstone, greywacke, felsite and andesite with vein-quartz and shale Sand: medium with fine and some coarse, quartz and rock fragments with some coal Fines: silt, disseminated, brown	1.8	2.0
	b 'Clayey' sand Gravel: trace of fine, vein-quartz, andesite and sandstone Sand: fine with medium and rare coarse, angular to subrounded, quartz with rock and coal fragments Fines: silt, micaceous, brown	5.0	7.0
Glaciolacustrine deposits	c 'Very clayey' sand Gravel: trace of fine Sand: fine with rare medium and trace of coarse, angular to subrounded, quartz with rock fragments Fines: silt, micaceous, brown	5.5	12.5
	Silt, laminated, with clay and sand seams and coal rich laminae, pale brown (5 YR 5/2) and brownish grey (5 YR 4/1). Containing some pebbles of sandstone, andesite and coal towards base	6.0	18.5
Till	Clay, stony, sandy, hard, greyish brown (5 YR 3/2), containing erratics of andesite, basalt, limestone, chert, mudstone and sandstone. Becoming dark grey (N 4) and rich in weathered mudstone and sandstone towards base	2.8+	21.3
Borehole terminated owing to slow progress			

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
a	3	67	30	0.2- 1.0	2	6	19	14	27	32	0	
				1.0- 2.0	3	32	55	3	3	4	0	
				Mean	3	20	39	8	14	16	0	
b	11	89	0	2.0- 3.0	11	60	27	1	1	0	0	
				3.0- 4.0	10	69	18	2	1	0	0	
				4.0- 5.0	17	69	13	1	0	0	0	
				5.0- 6.0	7	8	84	1	0	0	0	
				6.0- 7.0	10	74	16	0	0	0	0	
				Mean	11	56	32	1	**	0	0	
c	29	71	0	7.0- 8.0	22	73	5	0	0	0	0	
				8.0- 9.0	27	69	4	0	0	0	0	
				9.0-10.0	27	69	4	0	0	0	0	
				10.0-11.0	31	66	3	0	0	0	0	
				11.0-12.5	36	62	2	0	0	0	0	
				Mean	29	67	4	**	**	0	0	
a&b	9	83	8	Mean	9	47	33	3	4	4	0	
b&c	20	80	0	Mean	20	62	17	1	**	0	0	
a-c	18	78	4	Mean	18	56	20	2	2	2	0	

NT 26 SE 159

2514 6194

Auchendinny, Glencorse

Block C

Surface level +155.3m
(+509.5ft)
Groundwater level +152.8m
250mm percussion
August 1982

Overburden 0.3m
Mineral 6.3m
Waste 1.3m
Bedrock 1.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, light brown	0.3	0.3
Fluvioglacial sand and gravel	Sandy gravel Gravel: fine and coarse with some cobbles, subangular to rounded; white and red sandstones, andesite, basalt, felsite and greywacke with dolerite and vein-quartz Sand: coarse and medium with fine, angular to subrounded; quartz with rock fragments Fines: silt with clay, disseminated, dark reddish brown (10 R 3/4) to moderate brown (5 YR 3/4)	6.3	6.6
Till	Clay, stony, sandy, firm to stiff, moderate reddish orange (10 R 5/6)	1.3	7.9
Carboniferous (Passage Group)	Seatrock with siltstone and mudstone, finely bedded, micaceous, greyish orange (10 YR 7/4) to light grey (N 7), joints infilled with clay	0.8	8.7
	Sandstone, medium to coarse grained, poorly cemented and porous, mottled greyish orange (10 YR 7/4), containing some soft white mudstone pebbles	0.2+	8.9

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines		Sand		Gravel		
			from to	- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{8}$	$+\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
8	47	45	0.3- 1.0	14	11	12	14	19	30	0
			1.0- 2.0	9	10	13	17	21	22	8
			2.0- 3.0	8	7	12	18	22	33	0
			3.0- 4.0	5	8	23	18	20	15	11
			4.0- 5.0	7	7	17	25	33	11	0 §
			5.0- 5.7	6	6	28	30	23	7	0 §
			5.7- 6.6	5	9	26	26	25	9	0
			Mean	8	8	18	21	24	18	3

NT 26 SE 160

2606 6392

Moat, Lasswade

Block G₁

Surface level +164m
(+538ft)

Waste 10.6m+

Water struck at +161m
250mm percussion
August 1982

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, stony, silty, soft, mottled dark yellowish brown (10 YR 3/3), containing erratics of sandstone with andesite, coal and vein-quartz	1.6	2.0
	Clay, stony, very stiff, dusky yellowish brown (10 YR 3/2), containing angular to subrounded erratics of yellowish white, brown and red sandstones, greywacke, coal, shale, andesite, felsite and vein-quartz	8.6+	10.6

Surface level +166m
 (+543ft)
 Water seepage below +152m
 250 and 200mm percussion
 August 1982

Overburden 2.0m
 Mineral
 (including
 0.5m of
 waste) 19.0m
 Waste 4.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.3	0.3
Till	Clay, stony, sandy, firm, mottled, moderate brown (5 YR 4/4), with some pale grey leached patches, containing erratics of quartzite, sandstone and coal	1.7	2.0
Fluvioglacial sand and gravel	a Pebbly sand Gravel: fine with a little coarse, subangular to rounded, andesite, greywacke, sandstone, quartzite and vein-quartz with rare rhyolite, felsite and chert Sand: medium and fine with a little coarse, subrounded, quartz and rock fragments Fines: silt, micaceous, brown	5.0	7.0
	b 'Clayey' sand Gravel: traces of fine and coarse, angular to subrounded, coal with compositions as named above Sand: fine with medium and rare coarse, quartz, rock and coal fragments Fines: silt, disseminated and in seams from 7.0 to 8.0m, brown	6.0	13.0
Glaciolacustrine deposits	c 'Very clayey' sand, containing a laminated clayey, sandy silt seam from 18.5 to 19.0m Sand: fine with a little medium and trace of coarse, subrounded, quartz, coal and rock fragments Fines: silt, disseminated and in seams, micaceous, brownish grey	8.0	21.0
	Silt, laminated, containing seams of sand and some coal debris, micaceous, brownish grey	4.0+	25.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines			Gravel			
						- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{8}$	$+\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
a	5	90	5	2.0- 3.0	8	24	60	3	5	0	0	
				3.0- 4.0	4	30	55	6	4	1	0	
				4.0- 5.0	4	25	55	10	5	1	0	
				5.0- 6.0	5	33	55	3	3	1	0	
				6.0- 7.0	4	48	45	2	1	0	0	
				Mean	5	32	53	5	4	1	0	
b	10	90	0	7.0- 8.0	10	47	41	2	0	0	0	
				8.0- 9.0	7	59	33	1	0	0	0	
				9.0-10.0	8	64	27	0	0	1	0	
				10.0-11.0	4	55	38	3	0	0	0	
				11.0-12.0	21	53	22	3	1	0	0	
				12.0-13.0	11	62	24	2	1	0	0	
				Mean	10	57	31	2	**	**	0	
c	22	78	0	13.0-14.0	26	65	8	1	0	0	0	
				14.0-15.0	16	78	6	0	0	0	0	\$
				15.0-16.0	39	58	3	0	0	0	0	\$
				16.0-17.0	20	71	9	0	0	0	0	\$
				17.0-18.5	15	79	6	0	0	0	0	\$
				19.0-20.0	16	77	6	1	0	0	0	\$
				20.0-21.0	25	72	3	0	0	0	0	\$
				Mean	22	72	6	**	0	0	0	
a&b	8	90	2	Mean	8	46	41	3	2	**	0	
a-c	14	85	1	Mean	14	56	27	2	1	**	0	

Surface level +153.0m
 (+502.0ft)
 Water struck at +137.8m
 250 and 200mm percussion
 August 1982

Overburden 0.3m
 Mineral 15.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy loam, light brown	0.3	0.3
Fluvioglacial sand and gravel	a Gravel Gravel: coarse and fine with some cobbles, subangular to well rounded, red and white sandstones, greywacke, dolerite, andesite, basalt, coal, felsite, vein-quartz, chert and rare quartzite Sand: medium and coarse with fine, angular to subrounded, quartz with rock fragments and coal Fines: silt with some clay, disseminated with some seams, moderate brown (5 YR 3/4)	5.1	5.4
	b Sandy gravel Gravel: coarse and fine with some cobbles, as above in shape and composition Sand: medium with coarse and fine, as above in shape and composition Fines: silt with some clay, disseminated	2.9	8.3
	c Gravel Gravel: coarse and fine with some cobbles, as above in shape and composition Sand: coarse, medium and fine, as above in shape and composition Fines: silt with some clay, disseminated	7.4+	15.7

Borehole terminated owing to obstruction

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
						from	to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4
a	6	43	51	0.3- 1.3	6	7	13	20	30	24	0
				1.3- 2.3	6	9	12	16	29	28	0
				2.3- 3.3	8	6	25	17	19	25	0
				3.3- 4.3	6	8	20	14	20	32	0
				4.3- 5.4	4	8	21	16	23	28	0
				Mean	6	8	18	17	24	27	0
b	8	66	26	5.4- 6.3	7	7	34	17	14	13	8
				6.3- 7.4	8	13	52	11	5	11	0
				7.4- 8.3	8	11	37	13	15	16	0
				Mean	8	11	42	13	11	13	2
c	6	37	57	8.3- 9.5	6	5	11	18	23	37	0
				9.5-10.5	6	7	12	17	21	33	4
				10.5-11.5	8	8	15	18	23	24	4
				11.5-12.5	6	9	14	19	22	21	9
				12.5-13.5	8	7	13	18	25	20	9
				13.5-14.5	5	9	9	10	20	42	5
				14.5-15.7	6	16	15	6	16	32	9
				Mean	6	9	13	15	21	30	6
a&c	6	39	55	Mean	6	8	15	16	22	30	3
a-c	7	44	49	Mean	7	9	20	15	20	26	3

Surface level +162.2m
(+532.2ft)
Water struck at +154.7m
250 and 200mm percussion
August 1982

Overburden 5.8m
Mineral 6.0m
Waste 9.2m
Bedrock 0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pebbly, brown	0.2	0.2
Till	Clay, stony, sandy and silty in parts, weathered to 0.4m, firm becoming hard, greyish brown (5 YR 3/2) to moderate brown (5 YR 3/4) but leached in upper parts, containing erratics of fresh and weathered basalt, rotted red, green and black muddy sandstones, some andesite, shale and coal. Below 2.5m clay becomes dusky brown (5 YR 2/2) to moderate brown (5 YR 3/4), less pebbly, harder and contains some sandy partings	3.6	3.8
Fluvioglacial sand and gravel	Silt, sandy, micaceous, moderate yellowish brown (10 YR 5/4)	2.0	5.8
	'Clayey' sand Gravel: traces of fine and coarse, angular to rounded, sandstone with andesite, greywacke, shale, dolerite, limestone and porphyry Sand: fine with medium and rare coarse, subrounded, quartz with some rock fragments and coal debris, faintly bedded between 4.8 and 6.0m Fines: silt, disseminated, moderate yellowish brown (10 YR 5/4), becoming greyish below 10.5m	6.0	11.8
Till	Clay, stony, sandy, firm to hard, brownish grey (5 YR 4/1) to dusky brown (5 YR 2/2), containing small, angular erratics of chert, sandstones and mixed igneous rocks together with rounded pebbles and boulders of andesite, fresh and weathered basalts, greywacke, chert and porphyry	9.2	21.0
Carboniferous (Limestone Coal Group)	Mudstone and seatrock, black to medium grey, hard in parts with traces of coal	0.8+	21.8

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
10	90	0	5.8-	6.8	11	60	27	1	1	0	0
			6.8-	7.8	8	78	14	0	0	0	0
			7.8-	8.8	6	55	39	0	0	0	0
			8.8-	9.8	6	51	43	0	0	0	0
			9.8-	10.8	8	58	34	0	0	0	0
			10.8-	11.8	20	58	17	2	2	1	0
			Mean		10	60	29	1	**	**	0

Surface level +143m
(+469ft)
Groundwater level at +124m
250 and 200mm percussion
August 1982

Overburden 2.0m
Mineral 1.4m
Waste 6.1m
Mineral 15.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey, brown	0.2	0.2
Till	Clay, stony, sandy, silty, firm, mottled, orangey reddish brown, becoming more sandy with depth and containing angular to rounded erratics of red and yellow sandstones, coal, shale, felsite, andesite, vein-quartz, greywacke and dolerite	1.8	2.0
Fluvioglacial sand and gravel	a 'Very clayey' pebbly sand Gravel: fine with coarse, angular to subangular, sandstone with shale, andesite, porphyry and felsite and rare greywacke, vein-quartz and psammite Sand: fine with medium and a little coarse, subrounded, quartz with some rock fragments Fines: silt with clay, disseminated and in seams, moderate brown (5 YR 4/4)	1.4	3.4
Glaciolacustrine deposits	Silt, clayey, sandy, laminated in part, firm, micaceous, greyish brown to moderate brown (5 YR 3/4) with seams of reddish brown clay to 4.4m. Containing rare pebbles of sandstone and coal	6.1	9.5
	b 'Very clayey' sand Gravel: trace of fine Sand: fine with some medium and trace of fine, subrounded, quartz with coal fragments Fines: silt with clay, disseminated and in seams, moderate brown (5 YR 3/4)	2.3	11.8
Fluvioglacial sand and gravel	c 'Clayey' sandy gravel Gravel: coarse and fine with some cobbles, angular to well rounded, greywacke, felsite, andesite, porphyry, basalt, red, yellow and grey sandstones with vein-quartz, chert and limestone Sand: fine with medium and some coarse, angular, quartz and rock fragments Fines: silt and clay, disseminated, dusky yellowish brown (10 YR 3/2)	3.2	15.0
Glaciolacustrine deposits	d 'Clayey' sand Gravel: trace of fine, angular to rounded, greywacke, andesite, shale, felsite, sandstone, dolerite and tuff Sand: fine with some medium and trace of coarse, subrounded, quartz with rock fragments Fines: silt and clay, disseminated and as laminated seams below 21.0m, moderate brown to greyish brown	10.0+	25.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines	Sand			Gravel		
						$-\frac{1}{8}$	$+\frac{1}{8}-\frac{1}{4}$	$+\frac{1}{2}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$ mm
a	40	56	4	2.0- 3.4	40	33	18	5	3	1	0	
b	23	77	0	9.5-11.8	23	62	15	**	**	0	0	
c	11	63	26	11.8-12.8	16	42	34	4	3	1	0	
				12.8-13.8	5	11	15	12	25	32	0	
				13.8-15.0	13	48	15	6	9	9	0	
				Mean	11	35	21	7	12	14	0	
d	15	85	0	15.0-16.0	16	70	10	3	1	0	0	
				16.0-17.0	11	77	12	0	0	0	0	
				17.0-18.1	13	55	32	0	0	0	0	
				18.1-19.1	9	52	39	0	0	0	0	
				19.1-21.0	11	74	15	0	0	0	0	
				21.0-23.6	20	72	8	0	0	0	0	
				23.6-25.0	22	75	3	0	0	0	0	
Mean	15	70	15	**	**	0	0					
a&c	20	61	19	Mean	20	34	20	7	9	10	0	
b&d	17	83	0	Mean	17	68	15	**	**	0	0	
b-d	16	78	6	Mean	16	60	16	2	3	3	0	
a-d	18	76	6	Mean	18	58	16	2	3	3	0	

Surface level +153m
(+501ft)
Water struck at +142m
250 and 200mm percussion
August 1982

Overburden 0.4m
Mineral 5.4m
Waste 0.4m
Mineral 1^o.1m†

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, gravelly	0.4	0.4
Fluvioglacial sand and gravel	a Gravel Gravel: coarse and fine with cobbles, subangular to well rounded, mainly durable, yellow and grey sandstones, felsite, porphyry, basalt, with rare dolerite, greywacke, andesite, vein-quartz, chert, tuff and 'Highland' rocks Sand: coarse and medium with fine, 'sharp', rock fragments with quartz and coal Fines: clay with silt, commonly coating pebbles, and as 10cm seam at 1.4m	5.4	5.8
Till	Clay, silty with some coarse sand and fine gravel, firm to stiff, moderate brown (5 YR 4/4), trace of crude lamination	0.4	6.2
Fluvioglacial sand and gravel	b 'Clayey' pebbly sand Gravel: fine and coarse with rare cobbles, subrounded to well rounded, components as in gravel above Sand: medium and fine with coarse, 'sharp' then 'soft', quartz with rock fragments Fines: silt with laminae of clay, mainly between 7.2 and 9.7m, moderate brown (5 YR 4/4) to buff	4.5	10.7
	c Sand Gravel: fine and coarse, angular to subrounded, sandstone, andesite, felsite, carbonaceous shale, coal, vein-quartz and dolerite Sand: fine and medium with rare coarse, commonly 'soft', quartz with rock and coal fragments Fines: disseminated silt, dark grey-brown to pale brown	10.3	21.0
Glaciolacustrine deposits	d 'Very clayey' sand Gravel: trace of fine and coarse, subangular to subrounded, sandstone, andesite and vein-quartz Sand: fine with medium and trace of coarse, 'soft', quartz with rock and coal fragments Fines: silt with clay, disseminated and in seams, moderate brown	4.3+	25.3

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
						from	to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16
a	7	36	57	0.4- 1.4	6	6	19	14	20	27	8	
				1.4- 2.5	7	6	12	13	17	33	12	
				2.5- 3.5	7	6	11	14	20	36	6	
				3.5- 4.5	6	5	15	14	28	32	0	
				4.5- 5.8	8	5	19	17	32	19	0	
				Mean	7	6	15	15	24	28	5	
b	10	76	14	6.2- 7.2	4	11	48	14	15	8	0	
				7.2- 8.2	16	35	32	5	6	6	0	
				8.2- 9.7	14	42	42	1	1	0	0	
				9.7-10.7	6	29	34	7	12	12	0	
				Mean	10	31	39	6	8	6	0	
c	6	92	2	10.7-12.0	11	54	31	2	1	1	0	\$
				12.0-13.0	5	31	64	0	0	0	0	\$
				13.0-14.0	4	45	49	1	1	0	0	\$
				14.0-15.0	6	37	54	1	1	1	0	\$
				15.0-16.0	6	34	51	4	1	4	0	\$
				16.0-17.0	3	43	49	2	2	1	0	\$
				17.0-18.0	7	74	19	0	0	0	0	\$
				18.0-19.0	8	77	15	0	0	0	0	\$
				19.0-20.0	4	66	30	0	0	0	0	\$
				20.0-21.0	3	52	34	5	4	2	0	\$
				Mean	6	50	40	2	1	1	0	\$
d	29	71	0	21.0-22.0	23	59	14	2	1	1	0	\$
				22.0-25.3	31	65	4	0	0	0	0	\$
				Mean	29	65	6	**	**	**	0	
a&b	8	55	37	Mean	8	17	27	11	16	18	3	
c&d	13	85	2	Mean	13	54	30	1	1	1	0	
a-c	7	74	19	Mean	7	35	33	6	9	9	1	
a-d	11	73	16	Mean	11	40	28	5	7	8	1	

NT 26 SE 166

2793 6170

Gourlaw Cottages, Lasswade

Block G₃

Surface level +177m
(+580ft)
Water struck at +169m
250mm percussion
August 1982

Waste 12.0m
Bedrock 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground, soil and fill	0.3	0.3
Till	Clay, sandy, gravelly, stiff, mottled grey-orange brown. Below 3.0m more sandy, firm, with crude laminations and predominantly dark yellowish brown (10 YR 4/2). Clasts are mainly of Carboniferous sediments	4.4	4.7
	Clay, stony, very stiff, moderate brown, with subangular to subrounded clasts of sandstone, greywacke, andesitic lava and coal	7.3	12.0
Carboniferous (Lower Coal Measures)	Siltstone, micaceous, very soft, with numerous carbonaceous films and some rootlet casts, pale grey	0.3+	12.3

NT 26 SE 167

2790 6093

Shiells Strip, Lasswade

Block G₃

Surface level +194m
(+637ft)
Water not struck
250 and 200mm percussion
August 1982

Waste 15.1m
Bedrock 0.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground, blaes	0.2	0.2
Till	Clay, very silty, sandy, firm, clasts mainly of fine gravel size, mottled orange-brown and medium grey, becoming grey-brown with depth	0.8	1.0
	Gleyed till, quite soft, with tree roots	0.5	1.5
	Clay, stony, silty, sandy, very stiff, olive grey (5 Y 4/2), with angular to well rounded clasts of greywacke, sandstone, dolerite, impure limestone and shale	5.5	7.0
	Clay, stony, silty, very stiff, moderate brown (5 YR 3/4); clasts mainly of red and cream sandstones with andesite, shale, coal and some quartzitic sandstone	2.0	9.0
	Clay, sandy, pebbly, firm, dark yellowish brown (10 YR 4/3); clasts mainly of cream, orange and red sandstones with basalt, andesite, dolerite, ironstone and carbonaceous shale	6.1	15.1
Carboniferous (?Lower Coal Measures)	Sandstone, silty, fine grained, thinly bedded, micaceous, with clayey silty seams, mottled moderate yellowish brown (10 YR 5/4)	0.6+	15.7

Surface level +150m
 (+494ft)
 Water struck at +147m
 250mm percussion
 August 1982

Overburden 0.4m
 Mineral 5.4m
 Waste 6.2m
 Bedrock 0.4m†

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, gravelly	0.4	0.4
Fluvioglacial sand and gravel	Gravel Gravel: fine and coarse with cobbles, angular to well rounded, red, grey and white sandstones, felsite, porphyry, dolerite, basalt, greywacke, vein-quartz and rare psammite, ironstone and chert Sand: medium, coarse and fine, quartz and rock fragments Fines: disseminated silt and clay, orange-brown to moderate brown	5.4	5.8
Glaciolacustrine deposits	Silt and clay with fine sand, generally laminated, dark yellowish brown (10 YR 4/2) to dusky yellowish brown (10 YR 2/2)	1.2	7.0
Till	Clay, stony, sandy, silty, very stiff, dark to dusky yellowish brown (10 YR 3/2), with clasts of sandstone and shale with greywacke, tuff, andesite and felsite. Below 11.5m deposit is moderate brown (5 YR 4/4) and more sandy	5.0	12.0
Carboniferous (Lower Coal Measures)	Sandstone, medium to coarse grained, finely cross-bedded, slightly feldspathic, pale grey to white with rusty speckling	0.4+	12.4

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
6	36	58	0.4-	1.4	6	9	15	10	38	22	0
			1.4-	2.4	7	8	11	6	23	40	5
			2.4-	3.4	7	8	25	13	22	19	6
			3.4-	4.4	5	6	23	15	36	15	0 §
			4.4-	5.8	6	8	13	11	26	27	9 §
			Mean		6	8	17	11	29	25	4

Surface level +144m
 (+473ft)
 Water struck at +136m
 250 and 200mm percussion
 August 1982

Overburden 0.9m
 Mineral 2.1m
 Waste 10.1m
 Bedrock 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground, road material and fill	0.9	0.9
Fluvioglacial sand and gravel	Sandy gravel Gravel: fine and coarse with rare cobbles, mainly subangular to rounded, white, grey and red sandstones, basalt, felsite, porphyry, lava and greywacke Sand: medium with coarse and fine, quite 'sharp', quartz and rock fragments Fines: disseminated silt and clay, yellowish brown	2.1	3.0
Till	Clay, very silty, sandy, gravelly becoming pebbly by 3.5m, firm to stiff but becoming softer downwards, dark yellowish brown (10 YR 4/4), becoming moderate yellowish brown (10 YR 5/4) and finally dusky yellowish brown (10 YR 3/2). Clasts chiefly cream and grey sandstones, felsite, andesite and shale. Gradational transition from underlying deposit	4.7	7.7
Glaciolacustrine deposits	Silt, clay, and fine sand, interlaminated, coal fragments, dusky yellowish brown (10 YR 3/2)	3.9	11.6
Till	Clay, silty, stony, very stiff and dense, greyish brown (5 YR 3/2), with clasts of greywacke, shale, sandstone and basalt	1.5	13.1
Carboniferous (Passage Group)	Sandstone, medium grained, very hard, quartzose; buff to pale beige	0.1+	13.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
8	52	40	0.9- 1.9	6	7	29	14	22	22	0
			1.9- 3.0	10	8	28	17	19	18	0
			Mean	8	8	28	16	20	20	0

Surface level +147m
 (+483ft)
 Water not struck
 250 and 200mm percussion
 August 1982

Overburden 0.3m
 Mineral 3.8m
 Waste 8.6m
 Bedrock 1.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	Sandy gravel, with pebbly sand from 2.3 to 3.4m Gravel: coarse and fine with some cobbles, subangular to rounded, yellow, brown, white and red sandstones, andesite, felsite, dolerite, shale, coal, vein-quartz and conglomerate Sand: medium with fine and coarse, subangular to subrounded, quartz with rock fragments and coal Fines: disseminated silt, mainly moderate brown (5 YR 3/4)	3.8	4.1
Till	Clay, stony, with rare irregular sandy laminae, stiff, moderate brown (5 YR 3/4), then dusky yellowish brown (10 YR 2/2), then dark yellowish grey (10 YR 4/2); with clasts of yellow, brown, white and red sandstones, shale, coal, andesite, felsite, greywacke and vein-quartz	8.6	12.7
Carboniferous (Lower Coal Measures)	Coal, bright and dull banded, with siltstone Siltstone, micaceous, carbonaceous, thinly bedded, with coaly streaks and rare fossil plant stems, brownish black (5 YR 2/1)	0.5 0.6+	13.2 13.8

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	- $\frac{1}{16}$	+- $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
6	59	35	0.3- 1.3	9	14	37	12	20	8	0
			1.3- 2.3	6	5	18	11	27	33	0
			2.3- 3.4	5	30	49	9	4	3	0
			3.4- 4.1	7	10	18	8	21	36	0
			Mean	6	15	34	10	17	18	0

NT 26 SE 171

2952 6162

Thornton, Carrington

Block G3

Surface level +160m
(+525ft)
Groundwater level +157m
250mm percussion
August 1982

Waste 6.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Clay, silty, with scattered clasts of sandstone and coal, crudely laminated with some coaly seams, dark yellowish brown (10 YR 4/2)	0.6	0.9
Till	Clay, silty, stony, firm, greyish brown (5 YR 3/2), with angular to subrounded clasts of red and cream sandstones, andesite, felsite, basic lava, coal, siltstone and greywacke	5.1+	6.0
Borehole terminated owing to rock obstruction and artesian groundwater conditions			

NT 35 NW 285

3045 5894

Redside, Carrington

Block E

Surface level +209m
(+685ft)
Water struck (perched) at
+207m
250mm percussion
July 1982

Waste 5.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey loam, moderate grey-brown	0.3	0.3
Till	Clay, stony, stiff, angular to rounded clasts up to 200mm diameter, mainly of greywacke with red and white sandstones, vein-quartz, dolerite, chert and coal, mottled moderate brown (5 YR 4/4) to greyish red (5 R 4/2) to 3.2m, becoming greyish brown (5 YR 3/2) to dark reddish brown (10 R 3/4) with depth	5.1+	5.4
Borehole terminated owing to slow progress			

NT 35 NW 286

3076 5818

Shaw Knowe, Temple

Block E

Surface level +219m
(+719ft)
Water not struck
Pit
August 1982

Waste 1.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey, brownish grey	0.3	0.3
Till	Clay, sandy, stony, firm to stiff, with clasts up to boulder size, of red, greyish white and brown sandstones, greywacke, limestone, coal, shale and dolerite; moderate brown, slightly reddish	1.3+	1.8

Surface level +227m
 (+744ft)
 Water struck (perched) at
 +224m
 250mm percussion
 August 1982

Overburden 0.8m
 Mineral 2.3m
 Waste 5.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, light sandy silty loam	0.8	0.8
Fluvioglacial sand and gravel	'Very clayey' pebbly sand Gravel: coarse and fine, rare from 1.8 to 2.5m, subangular to rounded, mainly greywacke and sandstone with andesite, porphyry, vein-quartz, limestone, coal, ironstone, chert, some carbonaceous shale and rhyolite Sand: fine with medium and some coarse, mainly subangular, quartz with rock, feldspar and coal fragments Fines: silt and clay, mainly in seams in upper part, but disseminated at base, moderate brown (5 YR 4/5) becoming moderate yellowish brown (10 YR 5/3) with depth	2.3	3.1
Till	Clay, sandy, stony, soft to 3.7m with gravelly seam from 3.6 to 3.7m, firm to 5.0m becoming stiff and overconsolidated; clasts include greywacke, sandstone, limestone, basalt and coal; greyish brown (5 YR 4/2 becoming 5 YR 3/2)	5.0+	8.1
Borehole terminated owing to rock obstruction			

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
26	61	13	0.8- 1.8	32	40	10	5	7	6	0
			1.8- 2.5	20	53	25	1	1	0	0
			2.5- 3.1	22	18	24	7	11	18	0 §
			Mean	26	39	18	4	6	7	0

NT 35 NW 288

3048 5718

Rosebery, Temple

Block E

Surface level +250.0m
(+820.2ft)
Water not struck
Pit
August 1982

Waste 1.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, greyish brown	0.4	0.4
Fluvioglacial sand and gravel	Sandy gravel Gravel: coarse and fine, subrounded to well rounded, brown, white and red sandstones, greywacke, coal and shale Sand: fine to medium, subrounded, quartz with rock fragments Fines: some disseminated silt and clay, moderate brown	0.4	0.8
Till	Clay, sandy, stony, firm to stiff, reddish brown, clasts up to boulder size, include yellow and white sandstones, coal and shale with greywacke	1.1+	1.9

NT 35 NW 289

3188 5993

Carrington Mill, Carrington

Block E

Surface level +161m
(+528ft)
Water not struck
250mm percussion
August 1982

Overburden 2.3m
Mineral 3.4m
Waste 0.7m
Mineral 1.0m
Waste 1.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, moderate to dark grey loam	0.2	0.2
Till	Clay, pebbly, sandy, silty, firm to 0.7m becoming stiff, with subangular to well rounded clasts of yellow sandstone, coal, limestone and vein-quartz with red sandstone, shale, dolerite and andesite; moderate brown (5 YR 4/4) to 0.7m, becoming light to moderate brown (5 YR 5/6) and finally mottled moderate reddish brown (10 R 4/6)	2.1	2.3
Glacial sand and gravel	a 'Clayey' gravel Gravel: coarse and fine with cobbles, subangular to well rounded, greywacke, red and white sandstones, coal, dolerite, felsite, siltstone, andesite and limestone Sand: coarse, medium and fine, angular to subangular, quartz, rock and coal fragments Fines: disseminated silt and clay, especially above 3.3m, moderate brown (5 YR 4/4)	3.4	5.7
Till	Clay, stony, firm to stiff, containing angular to well rounded clasts of greywacke, red and yellow sandstones, coal, limestone, quartz, dolerite, felsite and andesite; moderate brown (5 YR 4/4), locally greyish brown (5 YR 3/2)	0.7	6.4
	b 'Very clayey' sandy gravel Gravel: fine and coarse with cobbles, angular to well rounded, composition as above Sand: fine with medium and coarse, angular to subangular, quartz and rock fragments Fines: disseminated clay and silt, moderate brown (5 YR 3/4)	1.0	7.4

LOG

Geological classification	Lithology	Thickness m	Depth m
	Clay, stony, stiff, with angular to rounded clasts up to cobble size and similar in composition to the deposit above, greyish brown (5 YR 3/2)	1.0+	8.4
	Borehole terminated owing to rock obstruction		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines		Sand			Gravel		
				from	to	1/16	1/8-1/4	1/4-1	1-4	4-16	16-64	+64 mm
a	10	28	62	2.3-	3.3	14	7	10	11	23	31	4
				3.3-	4.4	7	8	11	10	23	33	8
				4.4-	5.7	9	7	9	12	27	36	0
				Mean		10	7	10	11	25	33	4
b	28	42	30	6.4-	7.4	28	23	11	8	13	10	7
a&b	14	31	55	Mean		14	11	10	10	22	28	5

NT 35 NW 290 3144 5907 Braidwood, Temple Block E

Surface level +194m
 (+638ft)
 Water struck (perched) at
 +192m
 250 and 200mm percussion
 August 1982

Waste 13.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loamy	0.3	0.3
Till	Clay, sandy, silty, stony, soft to moderately firm, mainly subangular to subrounded clasts of sandstone, basalt, greywacke, grit, limestone and coal	2.3	2.6
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: fine with coarse and rare cobbles, subangular to subrounded, mainly greywacke with sandstones, basalt, andesite, chert, shale, felsite, vein-quartz and porphyry Sand: fine and medium with coarse, subangular, quartz with some feldspar, coal and rock fragments Fines: disseminated silt and clay, moderate brown (5 YR 3/4)	0.8	3.4
Till	Clay, stony, stiff, with mainly angular clasts of crinoidal limestone with greywacke, quartzite, sandstone, shale and coal; brownish grey (5 YR 4/1)	10.4+	13.8
	Borehole terminated owing to rock obstruction		

NT 35 NW 291

3159 5688

Yorkston, Temple

Block E

Surface level +247m
 (+811ft)
 Water struck at +244m
 250mm percussion
 September 1982

Waste 9.7m
 Bedrock 1.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy then clayey loam, dark grey-brown	0.3	0.3
Till	Clay, sandy, stony, firm, containing angular to subrounded clasts of yellow, brown and red sandstones, shale, coal, greywacke and quartz; mottled reddish brown to yellow-brown and orange	2.1	2.4
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: fine with coarse, angular to rounded, yellow, brown and red sandstones, shale, coal, greywacke and vein-quartz with rare andesite and ironstone nodules Sand: fine and medium with coarse, subangular, quartz with rock fragments Fines: disseminated silt and clay, moderate brown (5 YR 3/4)	0.7	3.1
Till	Clay, stony, stiff, containing angular to subrounded clasts of brown, yellow and red sandstones, greywacke, siltstone, vein-quartz, shale, coal and felsite; dusky yellowish brown	6.6	9.7
Carboniferous (Limestone Coal Group)	Sandstone, medium to coarse grained, cross-bedded, quite porous, friable, soft at top. Some grey clay, probably joint infilling	1.3+	11.0

Surface level +276m
 (+906ft)
 Water not struck
 250 and 200mm percussion
 August 1982

Overburden 0.3m
 Mineral 1.6m
 Waste 11.8m⁺

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, sandy	0.3	0.3
Fluvioglacial sand and gravel	'Very clayey' sandy gravel Gravel: fine and coarse with cobbles, mainly subangular to subrounded, sandstone and greywacke with coal, felsite, andesite, vein-quartz, ironstone, dolerite, rare limestone and psammite Sand: fine with medium and some coarse, subangular to subrounded, quartz, rock and some coal fragments Fines: disseminated silt and clay, deposit partially claybound, light brown (5 YR 5/6)	1.6	1.9
Till	Clay, stony, very stiff, with small clasts, including sandstone, greywacke and limestone, light brown (5 YR 5/6) to moderate reddish brown (10 R 4/6), becoming medium grey (N 5) by 5.0m	4.4	6.3
	Clay, silty, stoneless, stiff, a chaotic assemblage of fragments of finely laminated silty clay derived from an earlier glaciolacustrine deposit; dusky yellowish brown (10 YR 3/2) and yellowish grey (5 Y 7/1)	2.7	9.0
	Clay, stony, very stiff, containing subangular to subrounded clasts chiefly of greywacke and sandstone; medium grey (N 5)	4.7+	13.7
Borehole terminated owing to slow progress.			

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel								
			from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
21	47	32	0.3- 1.3	20	26	18	8	16	12	0
			1.3- 1.9	24	24	11	5	9	12	15
			Mean	21	24	16	7	14	12	6

Surface level +280.8m
 (+921.3ft)
 Water not struck
 Pit
 August 1982

Overburden 0.7m
 Mineral 1.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, medium to dark brownish grey	0.4	0.4
Till	Clay, sandy, firm with some pebbles including sandstone, orange-brown, iron stained	0.3	0.7
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: coarse and fine with cobbles, subangular to rounded, white and red sandstones, dolerite, greywacke, shale and coal Sand: fine and medium with coarse, subangular, quartz with rock fragments Fines: silt and clay, disseminated with some seams, mottled reddish to orange-brown becoming medium brown and yellow-brown with depth	1.4+	2.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand	Gravel					
			from	to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
16	58	26	0.7-	2.1	16	32	20	6	11	15	0

Surface level +162m
(+531ft)
Groundwater level +156m
250 and 200mm percussion
August 1982

Overburden 1.9m
Mineral 5.5m
Waste 10.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, silty	0.3	0.3
Till	Clay, silty, stony, with clasts, mainly of sandstones and coal with greywacke, quartzite and felsite, light brown (5 YR 5/4)	1.6	1.9
Fluvioglacial sand and gravel	a Gravel Gravel: coarse and fine with cobbles, subangular to rounded, various sandstones with basalt, felsite, quartzitic grit, greywacke, limestone, chert, carbonaceous shale, granodiorite, porphyry and gneiss Sand: coarse and medium with fine, subangular to subrounded, quartz with rock and coal Fines: disseminated silt and clay, deposit claybound, moderate yellowish brown (10 YR 5/4)	2.1	4.0
	b 'Clayey' sandy gravel Gravel: coarse and fine with cobbles, subangular to rounded, composition as above Sand: medium and coarse with fine, subangular to subrounded, quartz and rock with coal and feldspar fragments Fines: mainly silt, disseminated and in seams, dark yellowish brown (10 YR 4/2), becoming brownish grey (5 YR 3/1), and light brownish grey (5 YR 5/1) with depth	3.4	7.4
	Silt, laminated, with sandy seams and some pebbles, more common at top, pale yellowish brown (10 YR 6/2)	1.2	8.6
Till	Clay, stony, very sandy to 9.1m then stiff and overconsolidated, greywacke clasts common between 9.5 and 10.5m. At 16.0m clasts include sandstone, greywacke, basalt, limestone and andesite; moderate brown (5 YR 3/4) initially, becoming greyish brown (5 YR 4/2) by 16.0m	9.2+	17.8
Borehole terminated owing to slow progress			

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
						from to	1/16	1/16-1/8	1/8-1/4	+1-4	+4-16
a	6	29	65	1.9- 3.0	6	4	5	12	34	32	7
				3.0- 4.0	6	6	19	13	20	31	5
				Mean	6	5	12	12	27	32	6
b	10	56	34	4.0- 5.5	7	4	32	30	16	11	0
				5.5- 6.7	6	6	29	25	18	16	0 §
				6.7- 7.4	22	17	6	7	14	34	0 §
				Mean	10	7	25	24	16	18	0
a&b	8	45	47	Mean	8	6	20	19	21	24	2

Surface level c+285m
(c+935ft)
Water not struck
Pit
August 1982

Overburden 0.3m
Mineral 1.3m
Waste 0.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pebbly, sandy, medium brownish grey	0.3	0.3
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine with cobbles and boulders, subangular to rounded, yellow, white, brown and red sandstones, greywacke, coal, siltstone, shale, felsite and vein-quartz Sand: coarse and medium with fine, subangular to subrounded, quartz with rock fragments Fines: disseminated silt, moderate brown	1.3	1.6
Till	Clay, sandy, stony, firm, angular to rounded clasts of sandstone, felsite, greywacke, coal, shale and dolerite; mottled medium brown with reddish patches	0.6+	2.2

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
4	32	64	0.3-	1.6	4	4	13	15	23	30	11

Surface level +195m
 (+639ft)
 Water not struck
 250mm percussion
 July 1982

Waste 1.9m
 Bedrock 3.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	Pebbly sand Gravel: fine and coarse, subangular to rounded, sandstone, basalt, andesite, limestone, grit and dolerite Sand: fine and medium with coarse, subangular to subrounded, quartz with rock and feldspar fragments Fines: some disseminated silt, moderate brown (5 YR 4/4)	0.3	0.5
Till	Clay, stony, sandy, with clasts mainly of pale and rust coloured sandstone with coal	1.4	1.9
Carboniferous (Limestone Coal Group)	Sandstone, fine grained, medium bedded, somewhat micaceous, weathered and broken, dark yellowish orange (10 YR 6/6) to light brown (5 YR 5/6)	1.1	3.0
	Sandstone, fine grained, thinly bedded, interbedded with carbonaceous siltstone with plant debris, pale grey (5 R 7/1)	1.0	4.0
	Mudstone, micaceous, carbonaceous, with thin leaves of siltstone containing fragments of carbonaceous matter	0.8	4.8
	Coal on seatearth, mainly clay, pale grey-brown, on siltstone, micaceous, carbonaceous	0.2+	5.0

Surface level +230m
 (+756ft)
 Water struck at +222m
 250mm percussion
 July 1982

Overburden 0.4m
 Mineral 8.4m
 Waste 4.5m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, sandy	0.4	0.4
Fluvioglacial sand and gravel	a Sandy gravel Gravel: fine and coarse, mainly subangular to subrounded, greywacke and sandstone with siltstone, limestone, andesite, basalt, felsite, chert, dolerite, ironstone, vein-quartz and rare coal; some rotten pebbles Sand: medium and coarse with fine, subangular to subrounded, quartz, rock and coal fragments Fines: disseminated silt and clay, moderate yellowish brown (10 YR 5/4)	3.0	3.4
	b Gravel Gravel: coarse and fine with cobbles of sandstone, otherwise as above Sand: coarse and medium with fine, as above Fines: as above	4.0	7.4
	c 'Clayey' pebbly sand Gravel: fine with coarse, subangular to rounded, composition as above but with less sandstone Sand: medium with coarse and some fine, as above Fines: as above	1.4	8.8
Till	Clay, stony, stiff, with many angular to subangular clasts of sandstone, shale, mudstone and volcanic rocks, greyish brown (5 YR 3/2)	4.5+	13.3

Borehole terminated owing to slow progress

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
a	8	47	45	0.4- 1.4	7	9	17	18	28	21	0	
				1.4- 2.4	8	11	25	13	24	19	0	
				2.4- 3.4	7	9	21	21	29	13	0	
				Mean	8	9	21	17	27	18	0	
b	7	29	64	3.4- 4.4	6	6	9	12	24	26	17	
				4.4- 5.4	8	4	10	10	24	21	23	
				5.4- 6.4	9	8	13	12	29	29	0	
				6.4- 7.4	7	6	12	13	24	27	11	
				Mean	7	6	11	12	25	26	13	
c	11	68	21	7.4- 8.3	11	7	55	12	10	5	0	
				8.3- 8.8	10	8	30	20	20	12	0	
				Mean	11	8	45	15	14	7	0	
a&b	7	36	57	Mean	7	7	15	14	28	22	7	
a-c	8	41	51	Mean	8	7	20	14	25	20	6	

Surface level c+278m
(c+912ft)
Water not struck
250 and 200mm percussion
July 1982

Overburden 0.2m
Mineral 8.0m
Waste 1.0m
Mineral 4.1m
Waste 2.4m
Mineral 1.2m
Waste 2.0m
Bedrock 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, sandy	0.2	0.2
Glacial sand and gravel	a 'Clayey' sand with rare seams of gravel from 5.2 to 7.2m Gravel: fine with trace of coarse, subangular to subrounded, greywacke and sandstone with coal, andesite, felsite, vein-quartz, shale, rare dolerite and psammite Sand: fine with medium and trace of coarse, subangular to subrounded, quartz, rock and feldspar fragments Fines: disseminated silt and clay, and silt seams at 2.8 and 3.8m, moderate yellowish brown (10 YR 5/4)	8.0	8.2
Glaciolacustrine deposits	Silt, very sandy, laminated, moderate yellowish brown (10 YR 5/4)	1.0	9.2
	b 'Very clayey' sand Gravel: rare fine and trace of coarse, angular to subrounded, composition as above Sand: fine with medium and trace of coarse, otherwise as above Fines: disseminated silt and clay, and silty clay seams below 7.2m, moderate yellowish brown (10 YR 5/4)	4.1	13.3
Till	Clay, pebbly, soft, displaying faint lamination, some silt seams, rare subangular clasts mainly of sandstone; pale brown (5 YR 5/2)	1.5	14.8
	Clay, pebbly, soft, rare small clasts of sandstone, limestone and coal	0.9	15.7
	c 'Very clayey' sandy gravel Gravel: fine, coarse and cobble, subangular to subrounded, composition as above Sand: fine with medium and some coarse, subangular, quartz and rock fragments Fines: disseminated silt and clay	1.2	16.9
	Clay, stony, sandy, with subangular clasts including sandstone and limestone; moderate yellowish brown (10 YR 5/4)	2.0	18.9
Carboniferous (Lower Limestone Group)	Sandstone, fine grained, hard, rooty, buff	0.3+	19.2

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
						from	to	$\frac{1}{16}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{8}$ -1	+1-4
a	16	83	1	0.2- 1.2	8	63	28	1	0	0	0
				1.2- 2.2	12	64	24	0	0	0	0
				2.2- 3.2	15	73	12	0	0	0	0
				3.2- 4.2	8	44	48	0	0	0	0
				4.2- 5.2	14	48	38	0	0	0	0
				5.2- 6.2	18	33	40	6	3	0	0
				6.2- 7.2	16	54	25	2	2	1	0
				7.2- 8.2	34	62	4	0	0	0	0
				Mean	16	55	27	1	1	**	0
b	24	76	0	9.2-10.2	18	77	5	0	0	0	0
				10.2-11.2	16	67	15	2	0	0	0
				11.2-12.2	29	55	14	1	1	0	0
				12.2-13.3	31	60	9	0	0	0	0
				Mean	24	64	11	1	**	**	0
c	24	50	26	15.7-16.9	24	35	10	5	9	8	9
a&b	18	81	1	Mean	18	58	22	1	1	**	0
a-c	19	78	3	Mean	19	56	21	1	1	1	1

NT 35 NW 299

3496 5932

Castlelaw Bridge, Borthwick

Block F

Surface level c+189m
(c+618ft)
Groundwater level +186m
250mm percussion
September 1982

Overburden 0.3m
Mineral 1.7m
Waste 3.0m
Bedrock 1.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, clayey, grey-brown	0.3	0.3
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: coarse and fine with rare cobbles, subangular to rounded, sandstone, andesite, ironstone, greywacke, vein-quartz, felsite, chert, dolerite and carbonaceous shale Sand: fine and medium with coarse, angular to subrounded, quartz with feldspar, rock and coal fragments Fines: silt with clay, mainly disseminated, moderate brown (5 YR 3/4 to 5 YR 4/4)	1.7	2.0
Till	Clay, silty, stony, moderately firm, clasts mainly of Carboniferous sediments with vein-quartz and some igneous rocks, greyish brown (5 YR 4/2) at top becoming moderate brown (5 YR 3/4)	2.0	4.0
	Silt, sandy, stony, soft, clasts mainly of sandstone, probably of local derivation, medium grey (N 5)	1.0	5.0
Carboniferous (Limestone Coal Group)	Sandstone, fine to medium grained, with carbonaceous and micaceous films, porous, indistinctly bedded (disturbed or distorted), mineralised locally (pyrites) and veined, pinkish grey (5 YR 7/1)	1.0+	6.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand			Gravel			
			from to	1/16	1/8-1/4	1/4-1/2	1/2-1	1-4	4-16	16-64	+64 mm
16	46	38	0.3- 1.3	18	26	16	7	17	16	0	
			1.3- 2.0	12	15	19	8	17	29	0	§
			Mean	16	22	17	7	17	21	0	

NT 35 NE 27

3583 5946

Black Bog Wood, Borthwick

Block F

Surface level +196.2m
(+643.7ft)
Groundwater level +184.7m
250 and 200mm percussion
July 1982

Overburden 0.3m
Mineral 5.1m
Waste 1.3m
Mineral 1.1m
Waste 0.4m
Mineral 8.0m
Waste 8.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, medium to dark brown	0.3	0.3
Fluvioglacial sand and gravel	a 'Clayey' sand Sand: fine with medium and rare coarse, mainly subrounded, quartz with some rock and coal fragments Fines: silt, disseminated and as thin seams, moderate yellowish brown (10 YR 5/4)	1.4	1.7
	b 'Clayey' pebbly sand Gravel: fine with coarse and rare cobbles, subangular to well rounded, greywacke, red and yellow sandstones, quartzite, vein-quartz, mudstone, dolerite, andesite, felsite and chert; mainly durable pebbles Sand: fine and medium with coarse, subrounded to rounded with subangular, quartz with some rock and coal fragments Fines: disseminated silt and seams of silt and clay, colour as above	3.7	5.4
Glaciolacustrine deposits	Silt, laminated, moderate brown, with thin seams of fine sand with coal fragments, and laminae of reddish brown clay	1.3	6.7
	c 'Very clayey' pebbly sand Gravel: fine with coarse, as above Sand: fine with some medium and coarse, composition as above Fines: seams of laminated silt	1.1	7.8
	Silt, laminated, moderate brown with partings of reddish brown clay and seams of fine, coaly sand	0.4	8.2

LOG

Geological classification	Lithology	Thickness m	Depth m
	d 'Clayey' sand Gravel: rare, fine, angular to subrounded, sandstone, greywacke and coal Sand: fine with some medium and trace of coarse coal, subrounded, quartz with some coal and rock fragments Fines: silt, disseminated and in seams, and clay laminae from 15.7m, moderate yellowish brown (10 YR 5/4) to moderate brown (5 YR 4/4)	8.0	16.2
	Silt, laminated, moderate brown (5 YR 3/4), with seams of fine, coaly sand and laminae of reddish brown clay; also containing dropstones of sandstone and greywacke	0.5	16.7
Till	Clay, stony, stiff, greyish brown (5 YR 3/2) to greyish red (5 R 4/2), containing angular to rounded clasts of greywacke, sandstone, felsite, quartzite, coal and vein-quartz	1.1	17.8
Glaciolacustrine deposits	Silt, laminated, moderate brown (5 YR 3/4) with seams of dark reddish brown clay	6.3	24.1
	Silt, with angular to subrounded clasts up to cobble size of greywacke with chert, quartzite and red sandstone	0.7	24.8
Till	Clay, sandy, stony, firm to stiff, moderate brown (5 YR 3/4) to greyish brown (5 YR 3/2), with angular to rounded clasts of greywacke with vein-quartz, chert, quartzite, dolerite, and yellow and red sandstones	0.3+	25.1

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
						from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16
a	17	83	0	0.3- 1.7	17	65	16	2	0	0	0
b	19	63	18	1.7- 3.0	31	38	14	5	10	2	0
				3.0- 4.5	8	23	28	10	17	14	0
				4.5- 5.4	20	37	35	4	3	1	0
				Mean	19	31	25	7	11	7	0
c	31	58	11	6.7- 7.8	31	48	6	4	8	3	0
d	14	86	0	8.2- 9.6	16	81	2	1	0	0	0
				9.6-10.8	15	80	5	0	0	0	0
				10.8-12.5	17	82	1	0	0	0	0
				12.5-14.6	12	85	3	0	0	0	0
				14.6-16.2	10	85	5	0	0	0	0
Mean	14	83	3	**	0	0	0				
a&b	18	69	13	Mean	18	42	22	5	8	5	0
c&d	16	83	1	Mean	16	79	3	1	1	**	0
a-d	17	77	6	Mean	17	65	10	2	4	2	0

Surface level +228m
(+748ft)
Groundwater level +210m
250 and 200mm percussion
July 1982

Overburden 4.0m
Mineral 11.2m
Waste 5.8m
Bedrock 2.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground, ash and stones	3.5	3.5
Head	Clay, sandy, stony, soft, moderate yellowish brown (10 YR 5/4)	0.5	4.0
	a 'Very clayey' sandy gravel Gravel: fine and coarse, mainly subangular, yellow and cream sandstones, basalt, greywacke, andesite, vein-quartz, coal and felsite Sand: fine, medium and coarse, angular to subrounded, quartz and rock fragments Fines: disseminated silt and clay, deposit claybound, dark yellowish brown (10 YR 4/2)	1.2	5.2
Fluvioglacial sand and gravel	b Sandy gravel Gravel: coarse and fine with rare cobbles of sandstone and limestone, mainly subrounded, composition as above with chert and dolerite; higher greywacke content below 10.0m Sand: medium with coarse and fine, mainly subangular to subrounded, quartz with feldspar, rock and coal fragments Fines: silt and clay, mainly disseminated, deposit somewhat claybound at top and from 8.5 to 9.5m, moderate to dark yellowish brown (10 YR 5/4 to 10 YR 4/2)	5.1	10.3
	c 'Clayey' pebbly sand, gravelly below 14.9m Gravel: fine with coarse, angular to subrounded, sandstone, coal and greywacke, but more varied from 14.9m Sand: medium and fine with some coarse, subangular to subrounded, quartz, coal and rock fragments with some feldspar Fines: mainly silt, associated with seams of fine sand, moderate brown (5 R 4/3)	4.9	15.2
Till	Clay, sandy, stony, moderately firm, brownish grey (5 YR 3/1); clasts include sandstones, basalt, silty sandstone, limestone, felsite and coal	3.0	18.2
	Clay, sandy, stony, clasts predominantly of a massive, soft, coarse grained, cream to pale grey sandstone; also limestone and basalt	2.1	20.3
	Clay, stony, coal and shale fragments common	0.7	21.0
Carboniferous (?Base of Limestone Coal Group)	Sandstone, fine to medium grained, locally micaceous, thinly bedded but not friable, locally cross-bedded, porous, moderately well cemented, pale to moderate yellowish brown (10 YR 6/2 to 10 YR 5/4), coarser seams paler, iron stained at base	2.3+	23.3

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
a	26	40	34	4.0- 5.2	26	14	14	12	19	15	0	
b	9	54	37	5.2- 6.2	12	16	35	12	11	14	0	
				6.2- 7.2	9	17	41	15	9	9	0	
				7.2- 8.5	8	10	28	20	13	5		
				8.5- 9.5	10	7	11	13	25	31	3	
				9.5-10.3	8	9	19	9	23	32	0	
			Mean	9	12	28	14	16	19	2		
c	12	81	7	10.3-11.2	9	44	39	4	2	2	0	
				11.2-12.5	11	30	52	3	4	0	0	
				12.5-13.5	13	39	30	7	7	4	0	
				13.5-14.5	15	40	39	5	1	0	0	
				14.5-15.2	11	20	39	12	13	5	0	
			Mean	12	35	40	6	5	2	0		
b&c	11	67	22	Mean	11	23	34	10	11	10	1	
a-c	12	64	24	Mean	12	22	32	10	12	11	1	

Surface level +225.2m
(+738.9ft)
Water struck at +207.8m
250 and 200mm percussion
July 1982

Overburden 0.3m
Mineral 11.7m
Waste 3.0m
Mineral 4.4m
Waste 4.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy pebbly loam, mid-brown	0.3	0.3
Fluvioglacial sand and gravel	<p>a Sandy gravel</p> <p>Gravel: fine and coarse, subrounded to rounded, greywacke with sandstone, felsite, fine grained acid and intermediate volcanic rocks, rare vein-quartz, chert, carbonaceous shale, quartzite and coal</p> <p>Sand: medium and coarse with fine, mainly subangular, quartz with rock fragments and some feldspar</p> <p>Fines: silt and clay, mainly disseminated, moderate brown (5 YR 4/4)</p>	3.7	4.0
	<p>b Gravel, appears claybound</p> <p>Gravel: fine and coarse with rare cobbles, subangular to rounded with rare well rounded, mainly durable pebbles, composition as above with red sandstone, dolerite and rare tuff and ironstone</p> <p>Sand: coarse, medium and fine, angular to rounded, quartz with rock fragments</p> <p>Fines: disseminated clay and silt, moderate brown (5 YR 4/4)</p>	5.7	9.7
	<p>c 'Very clayey' sand, pebbly to 10.0m</p> <p>Gravel: fine with coarse, subrounded to well rounded, composition as above</p> <p>Sand: fine with medium and rare coarse, subrounded, quartz</p> <p>Fines: silt, mainly in seams, moderate brown</p>	2.3	12.0
	Silt, sandy with trace of fine gravel, moderate brown	3.0	15.0
	<p>d 'Clayey' gravel</p> <p>Gravel: coarse and fine with cobbles, subangular to well rounded, yellow, white and red sandstones, greywacke, limestone, coal, dolerite, chert, vein-quartz, andesite and porphyry</p> <p>Sand: fine, medium and coarse, subangular to subrounded, quartz with rock fragments</p> <p>Fines: silt with clay, disseminated, greyish brown (5 YR 3/2)</p>	2.1	17.1
Glaciolacustrine deposits	<p>e 'Very clayey' sand</p> <p>Gravel: rare fine and trace of coarse, angular to rounded, composition as above</p> <p>Sand: fine with some medium and rare coarse, subrounded, quartz with some coal and rock fragments</p> <p>Fines: silt, disseminated and in seams, moderate brown (5 YR 3/4)</p>	2.3	19.4
	Silt, laminated, with fine sand partings and clay laminae which become more common with depth, containing rare dropstones of greywacke and sandstone at 21.4m, brownish grey (5 YR 4/1)	4.1+	23.5
	Borehole terminated owing to excessive overburden		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						- $\frac{1}{16}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
a	8	59	33	0.3- 1.4	7	4	30	20	18	21	0	
				1.4- 2.4	9	5	37	26	15	8	0	
				2.4- 3.4	8	6	28	26	21	11	0	
				3.4- 4.0	7	7	25	18	14	29	0	
				Mean	8	5	31	23	17	16	0	
b	9	41	50	4.0- 5.0	9	11	11	13	22	34	0	
				5.0- 6.0	11	8	13	16	26	26	0	
				6.0- 7.0	6	7	13	15	32	27	0	
				7.0- 8.0	8	9	13	21	32	17	0	
				8.0- 9.0	9	20	26	13	15	17	0	
				9.0- 9.7	11	14	11	10	21	33	0	
				Mean	9	11	15	15	25	25	0	
c	28	70	2	9.7-10.0	30	43	8	6	9	4	0	
				10.0-11.0	25	45	29	1	0	0	0	
				11.0-12.0	31	65	4	0	0	0	0	
				Mean	28	54	15	1	1	1	0	
d	11	33	56	15.0-16.0	12	16	17	7	20	28	0	
				16.0-17.1	10	11	7	9	23	29	11	
				Mean	11	13	12	8	22	28	6	
e	33	66	1	17.1-18.5	33	59	6	1	1	0	0	\$
				18.5-19.4	34	64	2	0	0	0	0	\$
				Mean	33	61	4	1	1	0	0	
a&b	8	48	44	Mean	8	9	21	18	22	22	0	
a&b&d	9	45	46	Mean	9	10	19	16	22	23	1	
a-d	12	50	38	Mean	12	17	19	14	18	19	1	
c&e	31	68	1	Mean	31	57	10	1	1	**	0	
a-e	15	52	33	Mean	15	23	17	12	16	16	1	

Surface level +232.6m
 (+763.1ft)
 Groundwater level +216.7m
 250 and 200mm percussion
 July 1982

Overburden 0.3m
 Mineral 4.2m
 Waste 17.5m⁺

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, pebbly loam, medium to dark grey	0.3	0.3
Fluvioglacial sand and gravel	a Gravel Gravel: fine and coarse with rare cobbles, subrounded to well rounded, greywacke, red and yellow sandstones, andesite, basalt, mudstone, felsite, quartzite, vein-quartz, chert and coal Sand: medium and coarse with fine, subangular to subrounded, quartz with rock fragments Fines: disseminated silt, dark yellowish brown (10 YR 4/2)	3.0	3.3
Glaciolacustrine deposits	b 'Very clayey' pebbly sand Gravel: fine and coarse, rounded, greywacke, felsite, andesite, sandstones, vein-quartz and coal Sand: fine with rare medium and coarse, subrounded, quartz with some coal fragments Fines: silt, disseminated and in seams, moderate brown (5 YR 3/4)	1.2	4.5
	Silt, sandy, with rare fine gravel composed of sandstone, greywacke, andesite, chert and coal; moderate brown (5 YR 3/4) to 8.2m becoming greyish brown	5.9	10.4
	Silt, sandy with coal fragments, laminated, containing laminae of reddish brown clay, dusky yellowish brown (10 YR 2/2) to medium grey	8.8	19.2
	Sand, silty, greyish brown (5 YR 3/2)	1.9	21.1
	Silt, laminated, with clay seams and rare fine sand partings, greyish brown to mid-grey	0.9+	22.0
	Borehole terminated owing to excessive overburden		

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Gravel						
					Fines	Sand					
			from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm	
a	5	45	50	0.3- 1.4	6	8	18	17	25	26	0
				1.4- 2.6	6	6	24	16	25	23	0
				2.6- 3.3	2	9	23	16	26	24	0
				Mean	5	7	22	16	26	24	0
b	32	62	6	3.3- 4.5	32	54	6	2	3	3	0
a&b	13	50	37	Mean	13	21	17	12	19	18	0

Surface level c+232m
(c+761ft)
Water struck (perched) at
c+226m
250 and 200mm percussion
July 1982

Overburden 0.5m
Mineral 8.1m
Waste 5.3m
Bedrock 5.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, clayey, some pebbles, pale brown (5 YR 5/2) to greyish brown (5 YR 3/2)	0.5	0.5
Fluvioglacial sand and gravel	a Sandy gravel Gravel: fine with coarse and rare cobbles, mainly subangular to rounded, chiefly greywacke with cream, red and green sandstones, andesite, chert, vein-quartz and some black shale and mudstone Sand: medium with coarse and some fine, angular to rounded, quartz and rock fragments Fines: silt, moderate brown	5.0	5.5
	b Sand with pebbles Gravel: fine with coarse, angular to rounded, sandstone and volcanic rocks Sand: medium with fine and some coarse, subangular to well rounded, quartz with rock fragments Fines: some silt, moderate brown (5 YR 4/4) to moderate reddish brown (10 R 4/6)	2.0	7.5
	c Gravel Gravel: coarse and fine with cobbles of sandstone, mainly subangular to rounded, components as above plus ironstone nodules and felsite Sand: medium with fine and coarse, as above Fines: silt, moderate brown	1.1	8.6
Glaciolacustrine deposits	Silt, clayey, finely laminated in parts, micaceous, with some angular to rounded pebbles of sandstone, andesite and vein-quartz. Deposit is greyish red (5 R 4/2) to 10.0m, brownish grey to 10.5m, becoming pale brown (5 YR 5/2) to moderate brown (5 YR 4/4)	4.3	12.9
Till	'Very clayey' sandy gravel Gravel: fine with coarse, angular to subrounded, chiefly cream and iron-stained sandstones with greywacke, vein-quartz, some quartzite, andesite, felsite and dolerite Sand: fine and medium with coarse, angular to subrounded, quartz and rock fragments Fines, silt and clay, brown, becoming redder with depth	1.0	13.9
Carboniferous (Calciferous Sandstone Measures)	Sandstone, broken, fine grained, compact, massive, very light grey (N 8)	1.0	14.9
	Seaclay, grey, mottled red, rooty, soft with sandstone, fine grained, massive	1.6	16.5
	Siltstone, muddy, mottled red, with sandstone, fine grained, massive, purplish and greenish grey	1.0	17.5
	Siltstone, purple; mudstone, silty, mottled dark red and pale green; seaclay, grey soft with brown root casts	1.1	18.6
	Sandstone, silty, soft, clean, massive, possibly sparse root casts, finely mottled, purplish grey	1.0+	19.6

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
				from to	- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{8}$	$+\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
a	5	50	45	0.5- 1.5	4	6	26	16	34	14	0
				1.5- 2.5	4	5	19	11	29	25	7
				2.5- 3.5	7	10	33	10	25	15	0
				3.5- 4.5	5	5	33	19	27	11	0
				4.5- 5.5	3	7	32	20	30	8	0
			Mean	5	7	28	15	29	15	1	
b	1	95	4	5.5- 6.5	1	9	86	2	2	0	0
				6.5- 7.5	1	14	72	5	5	3	0
				Mean	1	11	80	4	3	1	0
c	2	38	60	7.5- 8.6	2	7	25	6	23	32	5
a&c	4	48	48	Mean	4	7	28	13	28	18	2
a-c	3	59	38	Mean	3	8	40	11	22	14	2

Surface level +286.4m
 (+939.6ft)
 Water seepage at +271.4m
 250 and 200mm percussion
 August 1982

Overburden 6.5m
 Mineral 2.2m
 Waste 10.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, clayey, light brown	0.4	0.4
Glacial sand and gravel	'Clayey' sandy gravel Gravel: fine and coarse, subangular to subrounded, greywacke and sandstones with limestone, andesite, basalt, dolerite, felsite, vein-quartz, chert, ironstone and shale Sand: fine and medium with coarse, subangular to subrounded, quartz, feldspar and rock fragments Fines: disseminated silt and clay, deposit claybound locally, light brown (5 YR 5/6)	0.9	1.3
Till	Clay, sandy, stony, stiff, with angular to subangular clasts, mainly of greywacke, sandstone and volcanic rocks, brownish grey (5 YR 4/1)	5.2	6.5
	'Clayey' sandy gravel Gravel: fine with coarse, angular to subrounded, composition as in gravel component above Sand: medium and fine with coarse, subangular, quartz, feldspar and rock fragments Fines: disseminated silt and clay, deposit claybound locally, moderate yellowish brown (10 YR 5/4)	2.2	8.7
	Clay, sandy, stony, stiff, as above, but greyish brown (5 YR 3/2)	10.3+	19.0
Borehole terminated owing to excessive overburden			

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel								
			from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
18	51	31	6.5- 7.5	14	15	20	11	22	18	0
			7.5- 8.7	21	22	22	12	16	7	0
			Mean	18	19	21	11	19	12	0

Surface level +301.51m
 (+898.21ft)
 Water not struck
 250 and 150mm percussion
 September 1982

Overburden 0.2m
 Mineral 7.1m
 Waste 5.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, sandy, pebbly, medium brown	0.2	0.2
Glacial sand and gravel	Gravel Gravel: coarse with fine and some cobbles, angular to rounded, greywacke with rare chert, andesite, sandstone, vein-quartz and andesitic tuff Sand: coarse with medium and fine, angular to subangular, quartz and greywacke fragments Fines: disseminated silt and clay, pebbles commonly clay coated, moderate brown (5 YR 3/4) to moderate reddish brown (10 R 4/6)	7.1	7.3
Till	Clay, sandy, stony, firm, crudely bedded in part, with angular to subrounded clasts of greywacke with siltstone, red and brown sandstones, vein-quartz, shale, coal and felsite; light brown (5 YR 5/6) to moderate reddish brown (10 R 4/6)	3.9	11.2
Lacustrine deposit	Silt, laminated in part, with seams of pebbly sand, containing root traces (replaced by iron oxide) locally, moderate brown (5 YR 4/4)	0.6	11.8
Till	Clay, sandy, stony, firm, as above	1.1+	12.9
Borehole terminated owing to rock obstruction			

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
9	25	66	0.2- 1.2	13	5	11	13	25	22	11
			1.2- 2.2	8	6	9	9	27	41	0
			2.2- 4.4	10	7	4	5	20	54	0
			4.4- 5.5	7	6	7	17	26	32	5
			5.5- 7.3	8	8	9	14	25	36	0
			Mean	9	7	7	11	24	40	2

Surface level +287m
 (+942ft)
 Water not struck
 Pit
 August 1982

Overburden 0.2m
 Mineral
 (including
 0.2m of
 waste) 1.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, medium grey	0.2	0.2
Glacial sand and gravel	'Clayey' pebbly sand Gravel: fine with coarse and some cobbles, subrounded to well rounded, sandstone, greywacke, coal, shale, vein-quartz, andesite and dolerite Sand: fine with medium and some coarse, subrounded, quartz with rock fragments Fines: disseminated silt, medium brown	1.3	1.5
Till	Clay, stony, firm to stiff, with clasts of sandstone, greywacke, shale, coal, felsite and vein-quartz, reddish brown	0.2	1.7
Glacial sand and gravel	'Clayey' pebbly sand Gravel: fine with rare coarse Sand: fine with medium and rare coarse, subangular to subrounded, quartz with some rock and coal fragments Fines: disseminated silt, yellowish brown	0.4+	2.1

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
13	70	17	0.2-	1.5	13	39	22	9	11	6	0

Surface level +293m
(+961ft)
Water struck at +276m
250 and 200mm percussion
September 1982

Overburden 0.2m
Mineral 1.0m
Waste 0.4m
Mineral 1.0m
Waste 3.0m
Mineral 2.3m
Waste 9.3m
Bedrock 1.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, peaty, dark brown	0.2	0.2
Glacial sand and gravel	a 'Very clayey' pebbly sand Gravel: fine with coarse, mainly subangular, brown, cream and red sandstones, greywacke, andesite, vein-quartz, shale, ironstone, schist and conglomerate Sand: fine with medium and some coarse, angular to subrounded, quartz with some rock fragments Fines: silt and clay, brown	1.0	1.2
Till	Clay, very sandy, pebbly, soft, brown	0.4	1.6
Glacial sand and gravel	b 'Very clayey' pebbly sand Gravel: fine and coarse, composition as above Sand: composition as above Fines: composition as above	1.0	2.6
Till	Clay, sandy, stony, silty in parts, firm, sand lenses present, clasts include red and yellow sandstones and greywacke with vein-quartz, mudstone and igneous rocks; greyish red (5 R 4/2)	3.0	5.6
Glacial sand and gravel	c 'Clayey' gravel Gravel: coarse and fine with cobbles, mainly subangular, red, cream and yellow sandstones and greywacke with quartzite, andesite, dolerite, andesitic tuff, vein-quartz and rare pelite and psammite Sand: fine with medium and coarse, quartz and rock fragments Fines: silt and clay, disseminated and in pebbly seams, brown	2.3	7.9
Till	Clay, stony, sandy in part, stiff, with clasts mainly of sandstone (common at base), mudstone and coal; greyish red (5 R 4/2) to moderate brown (5 YR 4/4)	6.1	14.0
	Clay, silty, stiff, laminated and sandy in part, sporadic clasts of coal, vein-quartz and waterworn sandstone; dusky yellowish brown (10 YR 2/2) to moderate brown (5 YR 3/4)	2.7	16.7
	Clay, sandy, stony, with subangular to rounded clasts of yellow and brown sandstones with black shale, coal, red mudstone, greywacke and limestone; moderate yellowish brown (10 YR 5/4)	0.5	17.2
Carboniferous (?Calciferous Sandstone Measures)	Sandstone, silty, fine grained, micaceous, dark yellowish orange (10 YR 6/6)	1.1+	18.3

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Fines	Sand			Gravel			
						from	to	$\frac{1}{16}$	$\frac{1}{16}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16
a	28	60	12	0.2-	1.2	28	32	20	8	9	3	0
b	34	53	13	1.6-	2.6	34	35	13	5	7	6	0
c	12	42	46	5.6-	6.6	19	24	13	7	11	15	11
				6.6-	7.9	6	15	13	12	23	27	4
				Mean		12	19	13	10	18	21	7
a&b	31	56	13	Mean		31	32	17	7	8	5	0
a-c	21	48	31	Mean		21	25	15	8	13	14	4

NT 35 SW 9

3119 5283

Mauldslic, Temple

Block D

Surface level +312.1m
(+1024.0ft)
Water not struck
250 and 200mm percussion
September 1982

Overburden 0.6m
Mineral 7.0m
Waste 1.9m
Mineral 3.1m
Waste 3.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, sandy, pebbly, medium brown	0.6	0.6
Glacial sand and gravel	a 'Clayey' sandy gravel Gravel: fine and coarse, subangular to well rounded, greywacke with red and brown sandstones, siltstone, shale, coal, vein-quartz and andesite Sand: medium and fine with coarse, subangular, quartz with rock fragments Fines: disseminated silt, moderate brown (5 YR 4/4)	1.1	1.7
	b 'Very clayey' sand with trace of fine gravel Sand: fine with some medium and rare coarse, subrounded, quartz with some rock fragments Fines: silt, disseminated and in seams, moderate reddish brown (10 R 4/6)	1.2	2.9
	c Pebbly sand Gravel: fine with coarse, subangular to well rounded, brown, white and red sandstones, greywacke, siltstone, shale, vein-quartz, rare felsite and coal which is common locally Sand: medium and fine with coarse, subangular to subrounded, quartz with rock and coal fragments Fines: disseminated silt, moderate brown (5 YR 4/4)	4.7	7.6
Glaciolacustrine deposits	Silt, very sandy, laminated, with coal fragments, moderate brown (5 YR 4/4)	1.9	9.5
	d 'Very clayey' sand with rare small pebbles Sand: fine with medium and rare coarse, subrounded, quartz with coal fragments Fines: silt, in seams, moderate brown (5 YR 4/4)	3.1	12.6

LOG

Geological classification	Lithology	Thickness m	Depth m
	Silt, sandy, clayey, laminated with clay films, moderate brown (5 YR 4/4), greyish brown (5 YR 3/2) and dusky brown (5 YR 2/2)	1.1	13.7
Till	Clay, stony, stiff, with angular to rounded clasts of red, brown, yellow and white sandstones, greywacke, siltstone, shale, coal and vein-quartz; dusky yellowish brown (10 YR 2/2)	2.8+	16.5
Borehole terminated owing to slow progress			

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages								
	Fines	Sand	Gravel		from	to	Fines		Sand		Gravel		
							$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
a	14	46	40	0.6-	1.7	14	17	19	10	21	19	0	
b	29	71	0	1.7-	2.9	29	64	6	1	**	0	0	
c	7	84	9	2.9-	3.7	6	20	54	12	7	1	0	
				3.7-	4.7	5	10	46	18	14	7	0	
				4.7-	5.7	7	38	43	7	5	0	0	
				5.7-	6.7	5	21	53	12	9	0	0	
				6.7-	7.6	10	74	16	0	0	0	0	
			Mean		7	32	42	10	7	2	0		
d	36	64	0	9.5-	12.6	36	48	14	2	0	0	0	
a&b	22	58	20	Mean		22	41	12	5	11	9	0	
a&c	8	77	15	Mean		8	29	38	10	10	5	0	
a-c	12	76	12	Mean		12	36	32	8	8	4	0	
a-d	19	72	9	Mean		19	39	27	6	6	3	0	

Surface level +286.0m
 (+938.3ft)
 Groundwater level +283.8m
 250 and 200mm percussion
 September 1982

Overburden 0.3m
 Mineral 15.1m
 Bedrock 0.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, sandy, pebbly	0.3	0.3
Alluvium	a Gravel Gravel: coarse and fine with cobbles, mainly subangular, chiefly greywacke with some vein-quartz Sand: coarse to fine, angular to subrounded but mainly subangular, quartz and rock fragments Fines: disseminated silt and clay, deposit claybound from 1.0m, dark yellowish brown (10 YR 4/2)	1.1	1.4
Glacial sand and gravel	b Gravel, markedly claybound Gravel: coarse and fine with cobbles, subangular to subrounded, mainly greywacke with some sandstone, andesite and felsite Sand: coarse and medium with fine, angular to subrounded, quartz and rock fragments Fines: disseminated clay, deposit tilloid locally, considerable fines loss owing to drilling method especially below 2.4m; moderate yellowish brown (10 YR 5/4) becoming greyish orange (10 YR 6/4) and dark yellowish orange (10 YR 6/6) with depth	9.1	10.5
Till	c Gravel, with a silty, clayey matrix Gravel: fine and coarse with some cobbles, mainly angular to subangular with some subrounded and rounded, composition as above Sand: coarse with medium and some fine, angular to subrounded, quartz and rock fragments Fines: disseminated clay with silt, deposit claybound, but considerable fines loss owing to drilling method; greyish orange (10 YR 6/5)	4.9	15.4
Ordovician	Greywacke and silty mudstone, fissile, colour bedded, olive grey (5 Y 4/2)	0.6+	16.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages								
	Fines	Sand	Gravel		from	to	Fines		Sand			Gravel	
							$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{2}-1$	$+1-4$	$+4-16$	$+16-64$	$+64$ mm
a	8	25	67	0.3-	1.4	8	5	9	11	26	41	0	
b	5	24	71	1.4-	2.4	10	6	9	10	28	37	0	
				2.4-	3.7	5	3	7	10	21	54	0	\$
				3.7-	4.7	5	2	4	10	27	42	10	\$
				4.7-	5.7	3	2	9	14	36	36	0	\$
				5.7-	6.7	3	2	9	11	36	31	8	\$
				6.7-	7.7	3	2	7	10	28	50	0	\$
				7.7-	8.7	4	2	13	19	37	25	0	\$
				8.7-	9.5	4	1	11	18	28	38	0	\$
				9.5-	10.5	5	2	8	19	31	35	0	\$
			Mean		5	2	9	13	30	39	2		
c	6	40	54	10.5-	11.5	5	3	15	23	32	22	0	\$
				11.5-	12.5	6	4	14	22	31	23	0	\$
				12.5-	13.5	5	5	17	19	31	23	0	\$
				13.5-	14.5	5	2	12	22	36	23	0	\$
				14.5-	15.4	8	6	14	23	36	13	0	\$
			Mean		6	4	14	22	33	21	0		
a&b	5	25	70	Mean	5	3	9	13	30	38	2		
a-c	5	29	66	Mean	5	3	10	16	31	34	1		

Surface level +263.3m
(+863.8ft)
Groundwater level +261.2m
250 and 200mm percusion
September 1982

Overburden 0.2m
Mineral 3.0m
Waste 3.1m
Mineral 2.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, gravelly	0.2	0.2
Alluvium	a Gravel, slightly claybound below 1.2m Gravel: cobble, coarse and fine, subangular to subrounded, mainly greywacke with sandstone, vein-quartz, chert and rare coal Sand: coarse with medium and fine, angular to subrounded, quartz and rock fragments Fines: disseminated silt and clay, dark yellowish brown (10 YR 4/2)	3.0	3.2
?Late-Glacial alluvium	Silt, sandy, with trace of fine gravel composed of greywacke and coal, moderate yellowish brown (10 YR 5/4)	1.8	5.0
	Silt, laminated, with clay films, and pebbles below 6.1m, mainly moderate yellowish brown (10 YR 5/4)	1.3	6.3
Glacial sand and gravel	b 'Clayey' gravel Gravel: coarse with fine and cobble, mainly subangular, greywacke with some vein-quartz, sandstone, rare felsite, andesite and quartzite Sand: coarse, medium and fine, angular to subrounded, quartz and rock fragments Fines: disseminated silt with clay, considerable fines loss owing to drilling method; moderate yellowish brown (10 YR 5/4)	2.3+	8.6
Borehole terminated owing to rock obstruction (possibly bedrock)			

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		Gravel							
					from	to	1/16	1/8-1/4	1/4-1	1-4	4-16	16-64
a	5	22	73	0.2- 1.2		2	2	5	10	18	38	25
				1.2- 2.0	6	4	8	15	25	42	0	
				2.0- 3.2	6	5	5	12	35	33	4	§
				Mean	5	4	6	12	27	36	10	
b	11	24	65	6.3- 7.3	20	7	5	8	21	39	0	§
				7.3- 8.6	4	4	8	15	19	42	8	§
				Mean	11	5	7	12	20	40	5	
a&b	7	22	71	Mean	7	4	6	12	24	39	8	

Surface level +251.66m
(+825.66ft)
Groundwater level +250.5m
250 and 200mm percussion
September 1982

Overburden 0.3m
Mineral 2.5m
Waste 4.6m
Mineral 1.1m
Waste 6.1m
Mineral 2.9m
Waste 0.4m
Bedrock 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil, loam, sandy, moderate brown	0.3	0.3
Alluvium	a Gravel Gravel: coarse with fine and cobble, mainly subangular to subrounded, many platy pebbles, chiefly greywacke with rare chert, vein-quartz, felsite, cream and red sandstones and tuff Sand: coarse and medium with fine, angular to subrounded, quartz with feldspar and rock fragments Fines: disseminated silt, greyish yellowish brown (10 YR 5/2)	2.5	2.8
?Late-Glacial alluvium	Silt, laminated, with seams of fine sand to 4.0m and clay laminae from 5.0m, partly colour laminated, colour variable, moderate yellowish brown (10 YR 5/4), becoming light olive grey (5 Y 5/2), medium light grey (N 6), light olive grey (5 Y 6/2), pale olive (5 Y 5/3) and finally greyish orange (10 YR 7/4)	4.6	7.4
Glacial sand and gravel	b Gravel Gravel: fine with coarse, cobbles at base, mainly subangular, commonly platy, greywacke, shale and grit with some sandstone, vein-quartz, felsite, chert and andesitic tuff Sand: coarse with medium and fine, angular to subrounded, quartz and rock fragments Fines: some disseminated silt, deposit claybound from 8.2m light olive grey (5 Y 5/2)	1.1	8.5
Till	Silt, stony, sandy, clayey, firm, clasts mainly greywacke, moderate yellowish brown (10 YR 5/4)	0.3	8.8
	Clay, stony, silty, stiff, clasts mainly of Carboniferous sediments with basalt, plus vein-quartz and felsite, dusky yellowish brown (10 YR 3/2)	2.4	11.2
	Clay, stony, firm, clasts mainly of greywacke with grit and dolerite, moderate brown (5 YR 4/4), laminated silt fragments incorporated in deposit from 12.0m	2.6	13.8
Glaciolacustrine deposits	Silt, laminated, with clay films, colour laminated, moderate yellowish brown (10 YR 5/4), moderate brown (5 YR 4/4) and light brown (5 YR 5/6)	0.8	14.6

LOG

Geological classification	Lithology	Thickness m	Depth m
Till	c Gravel, disaggregated stony sandy clay Gravel: coarse and fine with some cobbles, angular to subangular with some subrounded and rounded, mainly greywacke with some dolerite, basalt, felsite and chert Sand: coarse with medium and some fine, angular to subrounded, quartz and rock fragments Fines: disseminated silt and clay, but considerable fines loss owing to drilling method; moderate yellowish brown (10 YR 5/4)	2.9	17.5
	Clay, stony, soft to firm, predominantly composed of small fragments of shale and siltstone; medium grey (N 5) to dark grey (N 3) with a bluish hue	0.4	17.9
Ordovician	Greywacke, medium grained, hard, medium dark grey (N 4)	0.1+	18.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages								
	Fines	Sand	Gravel		Gravel								
					from	to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
a	5	25	70	0.3-	1.3	8	6	11	13	19	43	0	
				1.3-	2.8	3	5	6	11	20	44	11	\$
				Mean		5	5	8	12	20	43	7	
b	5	40	55	7.4-	8.5	5	8	11	21	36	19	0	\$
c	2	32	66	14.6-	17.5	2	4	7	21	29	33	4	\$
a&b	5	30	65	Mean		5	6	9	15	25	35	5	
a-c	4	30	66	Mean		4	5	8	17	27	35	4	

Surface level +82m
 (+270ft)
 Water struck at +79m
 250mm percussion
 September 1982

Overburden 0.3m
 Mineral 4.2m
 Waste 8.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	a Pebbly sand Gravel: fine with coarse, subrounded to well rounded, yellow and brown sandstones and andesite with greywacke, felsite, quartzite, vein-quartz and coal Sand: fine with medium and some coarse, subrounded, quartz with rock fragments Fines: silt, disseminated with seams, moderate brown (5 YR 4/4)	1.5	1.8
	b 'Clayey' sand Sand: fine with medium and rare coarse, subrounded, mainly quartz Fines: silt, disseminated and in seams, moderate brown (5 YR 4/4)	2.7	4.5
Glaciolacustrine deposits	Silt, laminated, moderate brown (5 YR 4/4), containing seams of fine sand and brownish grey (5 YR 4/1) clay laminae with some coal fragments	6.9	11.4
Till	Clay, sandy, stony, stiff, moderate brown (5 YR 3/4), containing angular to subrounded erratics of sandstone, shale, greywacke, felsite, andesite and vein-quartz	1.4+	12.8

Borehole terminated owing to slow progress

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{4}$	1	4	16	64
a	7	84	9	0.3- 1.8	7	46	34	4	7	2	0	
b	15	85	0	1.8- 3.0	12	47	40	1	0	0	0	
				3.0- 4.5	17	75	8	0	0	0	0	0
				Mean	15	63	22	**	**	**	0	
a&b	12	84	4	Mean	12	56	26	2	3	1	0	

Surface level +58m
 (+191ft)
 Water not struck
 250mm percussion
 September 1982

Overburden 0.7m
 Mineral 1.8m
 Waste 2.2m
 Mineral 2.9m
 Bedrock 0.2m+

LOG

Geological classification	Lothology	Thickness m	Depth m
	Soil	0.3	0.3
	Made ground	0.4	0.7
Glacial sand and gravel	a 'Very clayey' pebbly sand Gravel: fine with some coarse, subangular to rounded, red and white sandstones with felsite, andesite, porphyry, shale, coal, chert and vein-quartz Sand: fine with some medium and coarse, subangular to subrounded, quartz with rock fragments Fines: silt, disseminated and in laminated seams, moderate brown (5 YR 4/4) and light brown (5 YR 6/4)	1.8	2.5
	Silt, sandy, laminated, moderate brown (5 YR 4/4)	1.9	4.4
Till	Clay, sandy, stony, firm, dusky brown (5 YR 2/2), containing angular to subrounded erratics of sandstone, greywacke, coal, shale and felsite	0.3	4.7
	b 'Clayey' gravel Gravel: coarse, fine and cobble, angular to subangular, red micaceous sandstone with yellow sandstone and some coal, shale, dolerite and vein-quartz Sand: fine with medium and coarse, subangular, quartz and rock fragments Fines: disseminated silt and clay, dark reddish brown (10 R 3/4)	2.9	7.6
Carboniferous (Middle Coal Measures)	Sandstone, fine grained, micaceous, finely bedded, greyish red (5 R 4/2)	0.2+	7.8

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand	Gravel				
				from to	$\frac{1}{16}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
a	38	56	6	0.7- 2.5	38	43	8	5	5	1	0
b	19	40	41	4.7- 5.9	21	30	9	8	13	14	5
				5.9- 7.6	17	25	6	5	13	15	19
				Mean	19	27	7	6	13	15	13
a&b	26	47	27	Mean	26	33	8	6	10	9	8

Surface level +76m
 (+248ft)
 Water struck at +71m
 250 and 200mm percussion
 September 1982

Overburden 0.4m
 Mineral 6.0m
 Waste 9.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	0.4	0.4
Fluvioglacial sand and gravel	a 'Clayey' pebbly sand Gravel: coarse and fine, subangular to rounded, red, brown, white and green sandstones and andesite with quartzite, felsite, basalt, greywacke, coal and vein-quartz Sand: fine with medium and some coarse, angular to rounded, quartz and rock fragments Fines: silt, medium brown	2.0	2.4
Glaciolacustrine deposits	b 'Very clayey' sand Sand: fine with rare medium and trace of coarse, rounded, quartz and rock fragments Fines: silt, disseminated and in seams, micaceous with some coal debris, medium brown	4.0	6.4
	Silt, laminated, with seams of fine sand and clay laminae, micaceous and containing coal debris, brownish grey (5 YR 4/1) to dark grey (N 3)	5.3	11.7
Till	Clay, sandy, stony, stiff, brownish grey to moderate brown, containing erratics of sandstone, basalt, andesite and mudstone	4.0+	15.7

Borehole terminated owing to obstruction

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$\frac{1}{16}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
a	19	61	20	0.4- 1.4	25	24	21	9	12	9	0	
				1.4- 2.4	13	47	18	5	7	10	0	
				Mean	19	34	20	7	10	10	0	
b	28	72	0	2.4- 3.4	12	70	17	1	0	0	0	
				3.4- 4.4	37	59	4	0	0	0	0	
				4.4- 5.4	29	70	1	0	0	0	0	
				5.4- 6.4	35	63	2	0	0	0	0	
				Mean	28	66	6	**	0	0	0	
a&b	25	69	6	Mean	25	55	11	3	3	3	0	

Surface level +104m
 (+341ft)
 Water struck (perched) at
 +98m
 250 and 200mm percussion
 September 1982

Overburden 1.0m
 Mineral 2.0m
 Waste 11.2m
 Bedrock 2.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
	Made ground	0.9	1.0
Fluvioglacial sand and gravel	Sand, fining downwards Gravel: fine, subangular to rounded, andesite, sandstone, felsite, shale and greywacke Sand: fine with medium and rare coarse, subrounded, quartz with some rock and coal fragments Fines: silt, disseminated and in seams, light brown (5 YR 5/6)	2.0	3.0
Glaciolacustrine deposits	Silt, laminated, containing seams of fine sand and coal rich partings, moderate brown (5 YR 4/4) to greyish brown (5 YR 3/2)	9.1	12.1
Till	Clay, stony, greyish brown (5 YR 3/2) becoming light brown (5 YR 5/6) below 14.0m. Containing erratics of coal, shale, andesite, yellow and red sandstones, felsite, greywacke and vein-quartz	2.1	14.2
Carboniferous (Lower Coal Measures)	Sandstone, fine grained, cross-bedded, containing plant remains, weathered, pale yellowish orange (10 YR 8/6) to light brown (5 YR 5/6)	1.1	15.3
	Siltstone, finely bedded, micaceous, medium dark grey (N 4), containing sandstone ribs	0.1	15.4
	Sandstone, medium grained, massive, dark yellowish orange (10 YR 6/6)	0.9	16.3
	Seatclay, finely bedded, medium grey (N 5) with black carbonaceous remains	0.2+	16.5

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	- $\frac{1}{8}$	+ $\frac{1}{8}$ - $\frac{1}{4}$	+ $\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
9	90	1	1.0- 2.0	7	47	42	2	2	0	0
			2.0- 3.0	10	70	20	0	0	0	0
			Mean	9	58	31	1	1	0	0

Surface level +53m
 (+173ft)
 Water seepage at +50m
 250 and 200mm percussion
 September 1982

Overburden 0.2m
 Mineral 2.1m
 Waste 9.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	'Very clayey' sandy gravel Gravel: fine and coarse, subangular to rounded, sandstone with quartzitic sandstone, limestone, felsite, chert, rare shale, dolerite and greywacke Sand: medium, fine and coarse, subangular to subrounded, quartz with rock and coal fragments Fines: silt, disseminated and in seams, light brown (5 YR 5/6)	2.1	2.3
Glaciolacustrine deposits	Silt, laminated, micaceous, containing sandy seams, dark yellowish brown (10 YR 4/2)	2.9	5.2
Till	Clay, stony, stiff, dark yellowish brown (10 YR 4/2) to dusky yellowish brown (10 YR 2/2), containing angular to rounded erratics of sandstone, andesite, basalt, felsite, porphyry and limestone	4.6	9.8
	Clay, sandy, stony, stiff, moderate brown (5 YR 3/4) with a greyish red (10 YR 4/2) hue, containing angular to subrounded erratics of sandstone, greywacke, andesite, coal and shale	2.3+	12.1

Borehole terminated owing to obstruction

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
21	46	33	0.2- 1.2	14	15	18	10	25	18	0
			1.2- 2.3	27	17	21	11	18	6	0
			Mean	21	16	20	10	21	12	0

Surface level +64m
 (+211ft)
 Water struck (perched) at
 +61m
 250mm percussion
 September 1982

Overburden 0.2m
 Mineral 3.2m
 Waste 3.0m
 Bedrock 0.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: coarse and fine with some cobbles, subangular to well rounded, yellow and brown sandstones, quartzitic sandstone, felsite, dolerite, greywacke, andesite, quartzite, chert, porphyry, vein-quartz and rhyolite Sand: medium with fine and coarse, subangular to subrounded, quartz with rock fragments Fines: silt, disseminated, light brown (5YR 5/6) to moderate brown (5 YR 4/3)	3.2	3.4
Glaciolacustrine deposits	Silt, laminated, greyish yellowish brown (10 YR 5/2), containing clay laminae	2.0	5.4
Till	Clay, stony, sandy, firm, mottled pale brown (5 YR 5/2), containing erratics of sandstone with shale, andesite, coal, siltstone and dolerite	1.0	6.4
Carboniferous (?Upper Coal Measures)	Seatclay, containing thin seams of sandstone, weathered, stained, mottled pale red (5 R 6/2) and pale red purple (5 RP 6/2) with very pale green (10 G 8/2) patches	0.9+	7.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
10	51	39	0.2-	1.0	14	22	18	9	15	22	0
			1.0-	2.0	5	9	23	10	20	26	7
			2.0-	3.4	12	11	31	14	19	13	0
			Mean		10	13	26	12	18	19	2

Surface level +40m
 (+132ft)
 Water not struck
 250mm percussion
 September 1982

Overburden 1.2m
 Mineral 1.9m
 Bedrock 0.3m±

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
	Made ground	0.2	0.3
Alluvium	Clay, sandy, containing some coal fragments, moderate brown (5 YR 4/4)	0.9	1.2
	a 'Very clayey' pebbly sand Gravel: fine and coarse, subangular to rounded, sandstone, felsite, andesite, greywacke, coal and vein-quartz Sand: fine and medium with some coarse, angular to subrounded, quartz with rock and coal fragments Fines: silt, disseminated, light brown (5 YR 5/6) to moderate brown (5 YR 4/4)	0.8	2.0
	b Gravel Gravel: coarse and cobble with fine, subangular to rounded, red and white sandstones, andesite, basalt, felsite, greywacke, dolerite, chert and quartz Sand: coarse to fine, angular to subrounded, quartz with rock fragments Fines: silt and clay, disseminated, moderate brown (5 YR 4/4) to dark reddish brown (10 YR 3/4)	1.1	3.1
Carboniferous (?Middle Coal Measures)	Seatrock, silt-grade, laminated, grey with red and purple staining, containing root traces	0.3+	3.4

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Gravel						
					Fines	Sand					
			from to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm	
a	22	73	5	1.2- 2.0	22	38	31	4	3	2	0
b	5	25	70	2.0- 3.1	5	7	8	10	12	28	30
a&b	12	46	42	Mean	12	21	18	7	8	17	17

Surface level +34m
 (+112ft)
 Water not struck
 250mm percussion
 September 1982

Overburden 0.1m
 Mineral 2.8m
 Waste 4.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.1	0.1
Fluvioglacial sand and gravel	Sandy gravel Gravel: coarse and fine with some cobbles, subangular to rounded, brown, yellow, white and red sandstones, felsite, greywacke, dolerite, andesite, quartzite, coal, vein-quartz, conglomerate and chert Sand: medium with fine and coarse, subangular, quartz with rock fragments Fines: silt, disseminated and in rare seams, moderate brown (5 YR 4/4)	2.8	2.9
	Silt, laminated, containing seams of micaceous fine sand and coal fragments, moderate brown (5 YR 3/4) to light brown (5 YR 5/6)	0.8	3.7
Till	Clay, sandy, stony, stiff, dusky yellowish brown (10 YR 2/2), containing seams of laminated silt with sand and pebbles and angular to subrounded erratics of yellow, brown, white and red sandstones, greywacke, andesite, coal and shale	2.4	6.1
	Clay, sandy, stony, stiff, moderate brown (5 YR 3/4) with a reddish hue, containing angular to subrounded erratics of red and white sandstones, greywacke, felsite, andesite, coal and shale	0.9+	7.0
Borehole terminated owing to rock obstruction			

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines			Sand		Gravel		
			from	to	- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{8}$	$+\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
5	48	47	0.1-	1.7	6	14	24	10	20	19	7
			1.7-	2.9	4	13	21	13	20	29	0
			Mean		5	14	23	11	20	23	4

Surface level +48m
 (+156ft)
 Water struck (perched) at
 +46m
 250 and 200mm percussion
 September 1982

Overburden 0.2m
 Mineral 2.1m
 Waste 14.0m
 Bedrock 0.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	'Clayey' sandy gravel Gravel: fine and coarse with some cobbles, subangular to rounded, sandstone, andesite, felsite, greywacke, dolerite, basalt, chert and vein-quartz Sand: medium with fine and coarse, subangular to subrounded, quartz with rock fragments Fines: silt, disseminated in seams	2.1	2.3
	Silt, laminated, containing clay seams, tenacious, brownish grey (5 YR 4/1)	2.1	4.4
Till	Clay, stony, sandy, firm, brownish grey (5 YR 4/1) to greyish brown (5 YR 4/2) becoming moderate brown (5 YR 3/4) below 12.0m. Containing erratics of yellow, brown and red sandstones, andesite, dolerite, basalt, felsite, limestone, coal and shale	11.9	16.3
Carboniferous (Upper Coal Measures)	Sandstone, fine grained, slightly micaceous, massive, pale red (5 R 6/2)	0.7+	17.0

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand	Gravel				
			from to	- $\frac{1}{16}$	$+\frac{1}{16}$ - $\frac{1}{8}$	$+\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
18	47	35	0.2- 1.2	9	9	11	13	26	28	4
			1.2- 2.3	26	13	39	7	11	4	0
			Mean	18	11	26	10	18	15	2

NT 36 NW 346

3483 6936

Smeaton, Inveresk

Block A

Surface level +37m
(+121ft)
Water not struck
250mm percussion
September 1982

Waste 3.5m
Bedrock 0.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Clay, silty, sandy, plastic, micaceous, containing some coal debris and rare pebbles of sandstone and lava, mottled medium grey (N 5) and moderate brown (5 YR 4/4)	1.2	1.5
Till	Clay, stony, stiff, moderate brown (5 YR 3/4), containing erratics of sandstone, greywacke, lava and vein-quartz	2.0	3.5
Carboniferous (Middle Coal Measures)	Coal, bright and dull banded	0.8+	4.3

NT 36 NW 347

3421 6883

Pickle Dirt, Dalkeith

Block A

Surface level +37m
(+121ft)
Water level not recorded
250mm diameter
September 1982

Waste 7.1m
Bedrock 0.3m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	'Clayey' gravel Gravel: coarse and fine, subangular to subrounded, red and cream sandstones, greywacke, andesite, basalt, felsite, chert and vein-quartz Sand: medium, fine and coarse, subangular to subrounded, quartz with rock fragments Fines: silt and clay, disseminated, moderate yellowish brown (10 YR 5/4)	0.9	1.2
Till	Clay, stony, stiff, greyish brown (5 YR 3/2) becoming dusky brown (5 YR 2/2), containing erratics of sandstone, felsite, andesite, dolerite, coal, shale and porphyry	5.9	7.1
Carboniferous (Middle or Upper Coal Measures)	Siltstone, bedded, micaceous, containing rare plant remains, medium dark grey (N 4) to medium bluish grey (5 B 5/1)	0.3+	7.4

Surface level +50.5m
 (+165.6ft)
 Water not struck
 250 and 200mm percussion
 September 1982

Overburden 0.3m
 Mineral 3.3m
 Waste 11.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	a Pebbly sand Gravel: fine with coarse, mainly rounded, sandstone, felsite, andesite, shale, greywacke, porphyry, chert and vein-quartz Sand: medium with fine and rare coarse, subangular to rounded, quartz and rock fragments Fines: silt, disseminated, medium brown	2.0	2.3
	b Sandy gravel Gravel: fine with coarse, as above in shape and composition Sand: medium with coarse and fine, as above in shape and composition Fines: as above in composition and colour	1.3	3.6
Glaciolacustrine deposits	Silt, laminated, micaceous, containing seams of fine sand and clay laminae with some coal debris and rare pebbles of sandstone and andesite; brownish grey (5 YR 4/1) to light grey (N 7)	4.6	8.2
Till	Clay, sandy, stony, stiff, greyish brown (5 YR 3/2), containing angular to subrounded erratics of sandstone, andesite, basalt, mudstone and felsite	6.8+	15.0
Borehole terminated owing to rock obstruction			

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines			Gravel			
					from	to	mm	mm	mm	mm	mm
a	5	88	7	0.3- 1.3	3	30	59	3	4	1	0
				1.3- 2.3	6	21	58	6	6	3	0
				Mean	5	25	59	4	5	2	0
b	8	66	26	2.3- 3.6	8	13	40	13	18	8	0
a&b	6	80	14	Mean	6	20	53	7	10	4	0

Surface level +131.52m
 (+431.50ft)
 Water struck (perched) at
 129.6m
 250mm percussion
 September 1982

Overburden 0.2m
 Mineral 2.8m
 Waste 6.2m
 Bedrock 3.4m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	'Very clayey' pebbly sand Gravel: fine with coarse, angular to rounded, brown, cream and green sandstones, with greywacke, andesite, basalt, felsite, coal, shale and rare psammite Sand: fine and medium with coarse, rounded, quartz and rock fragments Fines: silt, micaceous, brown	2.8	3.0
Till	Clay, sandy, stony, very stiff, brownish black (5 YR 2/1) to olive black (5 Y 2/1) becoming dusky yellowish brown (10 YR 2/2) below 6.0m, containing angular to rounded erratics of sandstone, coal, limestone, andesite, greywacke and vein-quartz	6.2	9.2
Carboniferous (Limestone Coal Group)	Sandstone, yellow, weathered Mudstone, silty, greyish black (N 2), containing rare ironstone nodules, weathered, poorly bedded	2.2 1.2+	11.4 12.6

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages						
Fines	Sand	Gravel		Fines	Sand			Gravel		
			from to	- $\frac{1}{16}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
22	65	13	0.2- 1.2	21	30	16	11	16	6	0
			1.2- 2.5	30	36	21	8	4	1	0 §
			2.5- 3.0	3	9	46	30	7	5	0 §
			Mean	22	28	24	13	9	4	0

Surface level +109.2m
 (+358.3ft)
 Water not struck
 250mm percussion
 September 1982

Overburden 0.3m
 Mineral 6.5m
 Waste 4.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Glacial sand and gravel	Gravel Gravel: coarse and fine with cobbles, angular to well rounded, mainly durable, brown, red and cream quartzitic sandstones with limestone, greywacke, dolerite, felsite, psammite and vein-quartz Sand: medium with fine and coarse, angular to rounded, quartz with rock fragments Fines: silt, medium brown	6.5	6.8
Till	Clay, sandy, stony, very stiff, dark grey (N 3) to greyish black (N 2), containing angular to rounded erratics of sandstone, limestone, coal, mudstone and andesite	4.2+	11.0

Borehole terminated owing to slow progress

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	- $\frac{1}{16}$	+ $\frac{1}{16}$ - $\frac{1}{8}$	+ $\frac{1}{8}$ -1	+1-4	+4-16	+16-64	+64 mm
7	42	51	0.3-	1.8	8	9	13	10	21	29	10
			1.8-	2.5	6	10	25	8	15	24	12
			2.5-	3.5	7	15	31	7	14	18	8
			3.5-	4.5	5	13	26	6	16	29	5
			4.5-	5.5	8	19	22	8	15	21	7
			5.5-	6.8	5	9	15	13	26	32	0
			Mean		7	12	21	9	18	26	7

Surface level c+142m
(c+466ft)
Water seepage at c+120 m
250 and 200mm percussion
August 1982

Overburden 0.2m
Mineral 17.1m
Waste 0.8m
Mineral 6.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Fluvioglacial sand and gravel	a Pebbly sand Gravel: fine with coarse, subangular to well rounded, red, yellow, brown and white sandstones, andesite, felsite, coal, shale and vein-quartz Sand: medium with fine and some coarse, subrounded, quartz with some rock and coal fragments Fines: silt, disseminated, moderate brown (5 YR 4/4)	3.9	4.1
	b 'Clayey' sand Gravel: traces of fine and coarse, subangular to rounded, coal, shale, sandstone and felsite Sand: fine and medium with very rare coarse, angular to subrounded, quartz with rock and coal fragments Fines: silt with clay, disseminated and in seams, moderate brown (5 YR 4/4)	13.2	17.3
	Clay, silty, sandy, firm, laminated, containing rare pebbles, dark yellowish brown (10 YR 4/2)	0.8	18.1
	c 'Clayey' sand Gravel: occurs below 22.2m, coarse and fine, coal Sand: fine with some medium and very rare coarse, rounded, quartz with coal debris Fines: silt with clay, disseminated and in seams, moderate yellowish brown (10 YR 5/4)	5.5	23.6
Till	d 'Very clayey' sandy gravel Gravel: coarse and fine, angular to well rounded, brown and white sandstones, andesite, basalt, greywacke, tuff, shale, rare felsite and vein-quartz Sand: fine with medium and some coarse, quartz and rock fragments Fines: silt and clay, disseminated, moderate brown (5 YR 4/4), deposit stiff	1.4+	25.0

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines	Sand			Gravel		
						from	to	- $\frac{1}{16}$	$\frac{1}{16}$ - $\frac{1}{8}$	$\frac{1}{8}$ -1	+1-4
a	9	75	16	0.2- 1.2	5	17	52	9	11	6	0
				1.2- 2.2	7	17	51	7	11	7	0
				2.2- 3.2	9	19	50	5	9	8	0
				3.2- 4.1	14	37	36	4	6	3	0
				Mean	9	22	47	6	10	6	0
b	11	89	0	4.1- 5.1	7	33	54	3	2	1	0
				5.1- 6.1	6	42	51	1	0	0	0
				6.1- 7.1	7	49	44	0	0	0	0
				7.1- 8.1	6	65	29	0	0	0	0
				8.1- 9.2	19	58	23	0	0	0	0
				9.2-10.2	8	62	30	0	0	0	0
				10.2-11.2	14	59	25	1	1	0	0
				11.2-12.2	7	68	25	0	0	0	0
				12.2-13.2	11	17	71	1	0	0	0
				13.2-14.2	9	27	63	1	0	0	0
				14.2-15.2	12	28	58	2	0	0	0
				15.2-16.2	14	26	57	3	0	0	0
				16.2-17.3	16	31	49	4	0	0	0
				Mean	11	44	44	1	**	**	0
c	10	88	2	18.1-19.1	11	77	12	0	0	0	0
				19.1-20.1	7	81	12	0	0	0	0
				20.1-21.1	8	39	53	0	0	0	0
				21.1-22.2	7	53	39	1	0	0	0
				22.2-23.6	15	66	8	5	2	4	0
				Mean	10	62	24	2	1	1	0
d	20	52	28	23.6-25.0	20	26	17	9	13	15	0
b&c	10	90	0	Mean	10	51	38	1	**	**	0
a-c	10	87	3	Mean	10	45	40	2	2	1	0
a-d	11	84	5	Mean	11	43	38	3	3	2	0

NT 36 SW 251

3236 6313

Millholm, Cockpen

Block G₂

Surface level c+70m
(c+230ft)

Water not struck

Pit

June 1982

Waste 1.7m
Bedrock 0.1m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Alluvium	Silt, clayey, sandy, pebbly, soft, medium brown, containing fine subangular quartz sand and rounded pebbles of sandstone, vein-quartz and coal	1.4	1.7
Carboniferous (Passage Group)	Sandstone, medium grained, yellow with red tinges, containing rare rounded pebbles of quartz	0.1+	1.8

NT 36 SW 252

3229 6297

Millholm, Cockpen

Block G₂

Surface level c+83m
(c+272ft)
Water not struck
250mm percussion
September 1982

Overburden 0.3m
Mineral 1.0m
Waste 2.6m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	'Very clayey' gravel Gravel: coarse with fine and cobbles, subangular to rounded, red, cream and orange sandstones, with dolerite, andesite, basalt, greywacke, siltstone, shale and vein-quartz Sand: fine and medium with coarse, angular to subrounded, quartz with rock fragments Fines: silt and clay, disseminated, mottled, mainly moderate brown (5 YR 4/4), deposit firm Clay, stony, firm becoming stiff, pale brown (5 YR 5/2) becoming brownish grey (5 YR 3/1) at 2.0m, containing erratics of sandstone with greywacke, coal, felsite and dolerite	1.0 2.6+	1.3 3.9
Borehole terminated owing to rock obstruction			

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand		Gravel				
			from	to	- $\frac{1}{8}$	+ $\frac{1}{8}$ - $\frac{1}{4}$	+ $\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
20	34	46	0.3-	1.3	20	14	13	7	8	28	10

NT 36 SW 253

3248 6094

Carrington Barns, Carrington

Block E

Surface level +132.90m
(+436.02ft)
Water not struck
250mm percussion
August 1982

Waste 8.9m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
Fluvioglacial sand and gravel	Sand, silty, moderate brown (5 YR 4/4) to moderate yellowish brown (10 YR 5/4), comprising fine subrounded quartz grains with coal fragments and silt in seams and disseminated	0.4	0.9
	Silt, clayey, sandy, laminated, soft to firm, moderate brown (5 YR 4/4)	0.3	1.2
Till	Clay, silty, sandy, stony, hard to stiff, moderate brown, containing angular to subrounded erratics of sandstone, coal, felsite, greywacke, andesite, mudstone and vein-quartz and pieces of the underlying silty clay deposit	1.0	2.2
Glaciolacustrine deposits	Clay, silty, laminated, tenacious, greyish brown (5 YR 3/2) to greyish red (5 R 4/2)	0.8	3.0
Till	Clay, stony, stiff, greyish red (5 R 4/2) becoming greyish brown (5 YR 3/2) below 3.8m, containing erratics of greywacke, sandstone, dolerite, vein-quartz, andesite, coal, limestone and quartzite	5.9+	8.9
	Borehole terminated owing to a limestone obstruction		

NT 36 SE 519

3634 6047

Wrights Houses, Borthwick

Block F

Surface level +212.6m
(+697.5ft)
Water not struck
250mm percussion
July 1982

Overburden 1.0m
Mineral 1.0m
Bedrock 2.7m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Till	Clay, sandy, stony, firm, mottled, mainly greyish brown (5 YR 4/2), containing angular to subangular erratics mainly composed of sandstone	0.6	1.0
	'Very clayey' sandy gravel Gravel: fine and coarse, angular to subangular, predominantly cream and yellow sandstones, with a trace of coal Sand: fine with some coarse and medium, subangular to subrounded, quartz and rock fragments Fines: silt and clay, disseminated, light brown (5 YR 5/6)	1.0	2.0
Carboniferous (Calciferous Sandstone Measures)	Sandstone, fine grained, thinly bedded, micaceous, containing carbonaceous partings, orange-brown	2.7+	4.7

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines	Sand			Gravel			
			from	to	— $\frac{1}{2}$	+ $\frac{1}{16}$ — $\frac{1}{4}$	+ $\frac{1}{8}$ —1	+1—4	+4—16	+16—64	+64 mm
25	48	27	1.0-	2.0	25	30	8	10	16	11	0

NT 36 SE 520

3778 6309

Vogrie House, Borthwick

Block F

Surface level +174.9m
(+573.8ft)
Groundwater level +168.1m
250 and 200mm percussion
July 1982

Overburden 0.6m
Mineral 4.7m
Waste 7.6m
Mineral 5.3m
Waste 2.1m
Mineral 2.1m†

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvioglacial sand and gravel	a 'Clayey' sand Gravel: fine and coarse, subangular to rounded, sandstone and greywacke with vein-quartz, grit, felsite and dolerite Sand: medium and fine with rare coarse, subangular to subrounded, quartz with feldspar, mica and rock fragments Fines: silt, disseminated and in seams, light brown (5 YR 5/4) to moderate yellowish brown (10 YR 5/4)	4.7	5.3
Glaciolacustrine deposits	Silt, sandy, laminated, with clay partings, micaceous, moderate brown (5 YR 4/4)	2.4	7.7
Till	Clay, sandy, stony, firm, light brownish grey (5 YR 5/1) becoming brownish grey (5 YR 3/1), containing subangular erratics of sandstone, vein-quartz, quartzite, basalt, felsite, limestone and coal	5.2	12.9
Glacial sand and gravel	b Pebbly sand Gravel: fine and coarse with rare cobbles, angular to rounded, sandstone with greywacke, limestone, felsite, andesite, dolerite and vein-quartz Sand: medium with fine and some coarse, subangular to rounded, quartz with coal, feldspar and rock fragments Fines: silt, disseminated, light brownish grey (5 YR 5/1)	2.3	15.2
Glaciolacustrine deposits	c 'Very clayey' sand Gravel: trace of fine, angular to subangular, sandstone, greywacke and felsite Sand: fine with some medium and rare coarse, subangular to subrounded, quartz with coal and some feldspar Fines: silt, disseminated and in seams, light brownish grey (5 YR 5/1)	3.0	18.2
	Silt, laminated, containing seams of fine sand, clay laminae and coal debris, brownish grey (5 YR 4/1)	2.1	20.3

LOG

Geological classification	Lithology	Thickness m	Depth m
Till	d Sandy gravel Gravel: coarse with fine and rare cobbles, subrounded, sandstone, greywacke, quartzite, basalt, vein-quartz, andesite, dolerite, porphyry, limestone, chert and ironstone Sand: medium, fine and coarse, angular to rounded, quartz and rock fragments with feldspar Fines: silt and clay, disseminated, moderate yellowish brown (10 YR 5/4) to dark yellowish brown (10 YR 4/2). Much of fines lost as a result of drilling action	2.1+	22.4

Borehole terminated owing to slow progress

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$\frac{1}{8}$	$\frac{1}{4}$ - $\frac{1}{2}$	$\frac{1}{2}$ -1	+1-4	+4-16	+16-64	+64 mm
a	11	85	4	0.6- 1.6	5	38	55	1	1	0	0	
				1.6- 2.7	5	34	53	1	2	5	0	
				2.7- 3.7	12	31	51	2	3	1	0	
				3.7- 4.3	8	25	59	3	4	1	0	\$
				4.3- 5.3	27	63	9	0	1	0	0	\$
				Mean	11	39	45	1	2	2	0	
b	7	72	21	12.9-13.9	5	15	22	14	21	23	0	\$
				13.9-15.2	8	34	52	4	2	0	0	\$
				Mean	7	25	38	9	11	10	0	
c	22	78	0	15.2-16.2	21	58	20	1	0	0	0	\$
				16.2-17.2	18	70	11	1	0	0	0	\$
				17.2-18.2	26	68	6	0	0	0	0	\$
				Mean	22	65	12	1	**	0	0	
d	6	53	41	20.3-21.6	5	12	21	11	18	30	3	\$
				21.6-22.4	9	27	28	11	13	12	0	\$
				Mean	6	18	24	11	16	23	2	
a&b	10	81	9	Mean	10	35	42	4	5	4	0	
a-c	13	81	6	Mean	13	44	34	3	3	3	0	
a-d	12	75	13	Mean	12	39	32	4	6	7	**	

Surface level +191.4m
 (+628.0ft)
 Water struck (perched) at
 +179.1m
 250 and 200mm percussion
 July 1982

Overburden 2.4m
 Mineral 3.6m
 Waste 6.8m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Till	Clay, very sandy, stony, firm, mottled greyish brown (5 YR 4/2), containing subangular to subrounded erratics of sandstone with coal and dolerite	2.2	2.4
Fluvioglacial sand and gravel	a 'Clayey' sand Gravel: trace of fine, subrounded, andesite, sandstone, greywacke, chert and vein-quartz Sand: fine with some medium and trace of coarse, subangular to subrounded, quartz with some feldspar and rock fragments Fines: silt, disseminated, moderate yellowish brown (10 YR 5/4)	2.6	5.0
	b 'Clayey' gravel Gravel: coarse with fine and cobbles, subangular to subrounded, red and yellow sandstones, dolerite, felsite, andesite, ironstone, coal and vein-quartz Sand: fine with medium and some coarse, subangular, quartz, feldspar and rock fragments Fines: silt and clay, disseminated and in some thin seams, moderate brown (5 YR 4/4)	1.0	6.0
Till	Clay, sandy, stony, firm to stiff, moderate brown (5 YR 4/5), containing erratics of orange sandstone with basalt	6.8+	12.8

Borehole terminated owing to rock obstruction

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Gravel						
					$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
			from to								
a	19	81	0	2.4- 3.6	8	77	15	0	0	0	0
				3.6- 5.0	29	66	5	0	0	0	
				Mean	19	72	9	**	**	0	0
b	17	39	44	5.0- 6.0	17	25	9	5	10	19	15
a&b	19	69	12	Mean	19	59	9	1	3	5	4

Surface level +151.9m
 (+498.4ft)
 Water seepage at +145.1m
 250mm percussion
 September 1982

Waste 6.8m
 Bedrock 0.4m†

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.6	0.6
Fluvioglacial sand and gravel	'Very clayey' sandy gravel Gravel: coarse with fine and cobbles, subangular to rounded, sandstone, greywacke, andesite, limestone, coal and quartz Sand: fine with medium and coarse, angular to rounded, quartz and rock fragments Fines: silt, disseminated, moderate brown	0.6	1.2
Till	Clay, sandy, stony, firm, moderate brown (5 YR 4/4), containing erratics of sandstone and coal	0.5	1.7
	'Very clayey' sandy gravel Gravel: fine and coarse, angular to subrounded, sandstone with andesite, greywacke, limestone, coal and vein-quartz Sand: fine with some medium and coarse, angular to rounded, quartz and rock fragments Fines: clay and silt, disseminated, brown	0.7	2.4
	Clay, sandy, stony, stiff, grey-brown, containing erratics of sandstone, dolerite, andesite, limestone, coal and vein-quartz	4.4	6.8
Carboniferous (Lower Limestone Group)	Seatrock, massive, with fine root casts, pale grey; and sandstone, fine grained, pale grey, with carbonaceous mudstone laminæ	0.4+	7.2

Surface level +195.1m
 (+640.1ft)
 Water seepage at +191.6 and
 +180.6m
 250 and 200mm percussion
 July 1982

Overburden 2.0m
 Mineral 12.5m
 Bedrock 2.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Till	Clay, stony, stiff, moderate brown, (5 YR 4/4), containing subangular to subrounded erratics of sandstone and andesite	1.7	2.0
Fluvioglacial sand and gravel	a 'Very clayey' sand Gravel: fine and coarse, subrounded, sandstone with greywacke, dolerite, andesite, vein-quartz, felsite and coal Sand: fine with some medium and rare coarse, subangular to subrounded, quartz, feldspar, rock and coal fragments Fines: silt, disseminated and in rare seams, moderate yellowish brown (10 YR 5/4)	5.5	7.5
	b Sandy gravel Gravel: fine with coarse, angular to rounded, sandstone and greywacke with mudstone, vein-quartz, andesite, felsite, chert, basalt and coal Sand: medium and fine with coarse, subangular to subrounded, quartz, coal and rock fragments Fines: silt and clay, disseminated, moderate brown (5 YR 3/4)	2.0	9.5
	c 'Clayey' pebbly sand Gravel: fine with coarse, subangular to subrounded, as above in composition Sand: fine with medium and some coarse, as above in shape and composition Fines: silt and clay, disseminated and in seams, moderate yellowish brown (10 YR 5/4)	5.0	14.5
Carboniferous (Lower Limestone Group)	Mudstone, silty, medium to dark grey, weathered at surface	2.0+	16.5

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages							
	Fines	Sand	Gravel		from to	Fines		Sand		Gravel		
						$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{8}$	$+\frac{1}{8}-1$	+1-4	+4-16	+16-64	+64 mm
a	28	70	2	2.0- 3.0	12	68	20	0	0	0	0	
				3.0- 4.0	33	53	11	1	1	1	0	
				4.0- 5.0	18	50	27	4	1	0	0	
				5.0- 6.0	33	60	7	0	0	0	0	
				6.0- 7.5	38	52	5	1	2	2	0	
				Mean	28	56	13	1	1	1	0	
b	7	53	40	7.5- 8.5	10	26	22	10	17	15	0	
				8.5- 9.5	4	12	24	13	31	16	0	
				Mean	7	19	23	11	24	16	0	
c	14	81	5	9.5-10.5	21	49	15	4	8	3	0	
				10.5-11.5	12	70	17	1	0	0	0	
				11.5-12.5	11	30	42	12	5	0	0	
				12.5-13.5	13	36	35	10	5	1	0	
				13.5-14.5	16	53	22	3	4	2	0	
				Mean	14	49	26	6	4	1	0	
a&c	21	75	4	Mean	21	53	19	3	3	1	0	
a-c	19	72	9	Mean	19	47	20	5	6	3	0	

Surface level +140.2m
 (+460.0ft)
 Water struck at +133.7m
 250mm percussion
 September 1982

Overburden 0.4m
 Mineral 2.2m
 Waste 3.5m
 Bedrock 1.2m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
Fluvioglacial sand and gravel	Gravel Gravel: coarse and fine with cobbles, angular to well rounded, sandstone with greywacke, andesite, vein-quartz, felsite, chert and coal Sand: medium, coarse and fine, angular to subrounded, quartz and rock fragments Fines: silt, micaceous, medium brown	2.2	2.6
Till	Clay, sandy, stony, stiff, olive black (5 Y 2/1) to brownish grey (5 YR 4/1), containing erratics of sandstone, greywacke, mudstone and andesite	3.5	6.1
Carboniferous (Limestone Coal Group)	Coal, splinty, mainly dull, containing some coaly mudstone	1.1	7.2
	Coal, splinty, dull with some bright ribs	0.1+	7.3

Grading

Mean for Deposit percentages			Depth below surface (m)	percentages							
Fines	Sand	Gravel		Fines		Sand		Gravel			
			from	to	$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
3	34	63	0.4-	1.4	5	12	15	13	26	29	0
			1.4-	2.6	2	8	11	10	20	25	24
			Mean		3	10	13	11	23	27	13

APPENDIX F

ANCILLARY BOREHOLE RECORD

NT SE 23 1

2293 5963

Bog Wood, Penicuik

Block C

Surface level not known
Groundwater level 12.8m below
surface level
Shell and auger
June 1967

Overburden 0.3m
Mineral 15.0m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.3	0.3
Fluvioglacial sand and gravel	a Gravel Gravel: coarse and fine with cobbles below 3.0m Sand Fines: silt	9.8	10.2
	b Sand Sand: fine to medium, brown	5.1+	15.3

Grading

	Mean for Deposit percentages			Depth below surface (m)	percentages						
	Fines	Sand	Gravel		Fines		Sand			Gravel	
					$\frac{1}{16}$	$\frac{1}{8}$ - $\frac{1}{4}$	$\frac{1}{4}$ -1	+1-4	+4-16	+16-64	+64 mm
a	1	40	59	0.3- 2.1	2	4	22	21	22	26	3
				2.1- 8.2	1	4	17	17	23	22	16
				8.2-10.2	No grading data available						
				Mean	1	4	18	18	23	23	13
b	No grading data available for this deposit										

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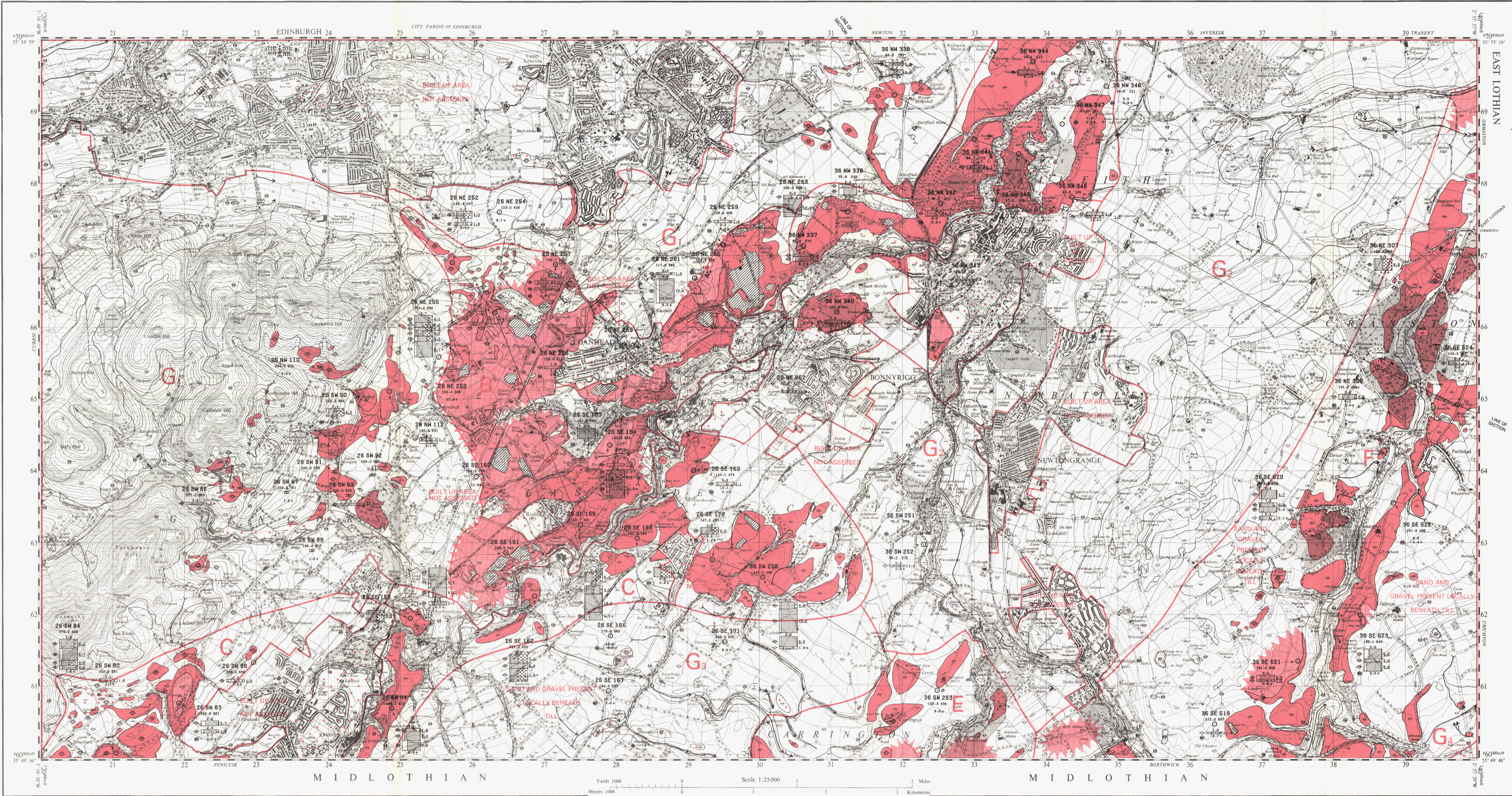
THE SAND AND GRAVEL RESOURCES OF THE COUNTRY AROUND DALKEITH, LOTHIAN REGION

Scale 1:25 000 or about 2 1/2 Inches to 1 Mile

ORDNANCE SURVEY
SHEETS NT 26 & NT 36
PROVISIONAL EDITION

THE SAND AND GRAVEL RESOURCES OF THE COUNTRY AROUND DALKEITH, LOTHIAN REGION
(NORTHERN SHEET)

This map should be read in conjunction with the accompanying report which contains details of the assessment of resources.



EXPLANATION OF SYMBOLS AND ABBREVIATIONS

- Made ground - waste and/or natural earth materials placed on the original ground surface MG-3
- Made ground - waste and/or natural earth materials placed in open cast workings MG-8
- Landfill L-1
- Drift Quaternary
- Peat P-1
- Alluvium, undifferentiated - narrow floodplains and terraces generally underlain by sand and gravel otherwise chiefly silt and clay A-81
- Alluvial cone - composed of sand, gravel and clay AC-5
- Late glacial alluvium - silt and clay with some sand and gravel LG-6
- High raised beach deposits - similar in composition to the alluvial terraces HRB-1
- Fluvio-glacial sand and gravel - terraced and almost flat-topped spreads of sand and gravel, generally well sorted, though clayey in part FL-33
- Glacial sand and gravel - mounded deposits of sand and gravel, well sorted to clay bound GS-91
- Glaciolacustrine deposits - deposits of fine sand, silt and clay with very rare pebbles, commonly laminated (gravel only in boreholes) G-7
- Till - typically a stiff silty, sandy clay with gravel clasts up to boulder size. A thin reddish brown silty sandy clay is recognized in the area between Temple and Carrington and Borthwick and Craigheroe overlying the other glacial deposits TL-21
- SOLID
- Bedrock (undifferentiated) - Much of the area is underlain by Carboniferous sediments, including shales, sandstones, coals and limestones. The Portland hills are comprised of lower Devonian volcanics including basalts, andesites and rhyolites, at their northeastern end sandstones of Upper Devonian age crop out.
- Worked ground (sand and gravel) as at February 1982 WG-8

BOUNDARY LINES

- Geological boundary
- Geological boundary following back-face of terrace, downward slope in direction of arrowhead
- Line marking back-face of terrace, downward slope in direction of arrowhead
- Glacial drainage channel, arrow shows direction of water flow
- Inferred boundary between categories of deposits at surface
- Inferred boundary between categories of deposits at depth
- Resource block boundary

BOREHOLES AND OTHER DATA SITE LOCATIONS

- Industrial Minerals Assessment Unit (I M A U) borehole
- Recorded exposure
- Shallow pit

I M A U BOREHOLES

- Registration Number: 26 SW 83
- Borehole Size: 100 mm
- Geological Classification: G-1
- Grading Diagram: 1:100
- Surface level in metres: 100
- Home OD (feet): 330
- Overburden: 10
- Waste: 10
- Mineral (sand and gravel): 10
- Bedrock: 10
- Thickness in metres: 10

Now:
If figures underlain by dots are used in the assessment of resources (i) the 'x' sign indicates that the base of the deposit was not reached (ii) the Geological Classification is given only for sand and gravel.

Registration Number:
Each I M A U borehole is identified by a registration number, for example 26 SW 83. The first numbers and letters refer to the quarter sheet and the final figures to the 100 m squares for that quarter. The unique designation for borehole 26 SW 83 is NT 26 SW 83.

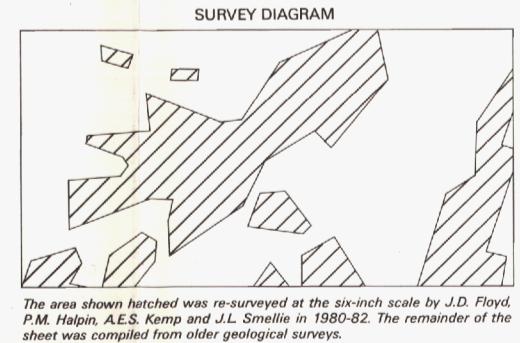
Grading Diagrams:
Each grading diagram shows the mean particle size distribution of a distinct deposit of mineral.

Now:
When grading data are not sufficiently detailed or are absent the grading diagram is crossed through and shown without content.

SHALLOW PITS:
Where space permits the locations of shallow pits providing assessment data are shown by a distinctive symbol, thus: Otherwise information is shown in the same way as for boreholes.

The representation on this map of a Road, Track, or Footpath, is in violation of the provisions of a right of way.

Geological lines taken from surveys at the six-inch scale between 1859 and 1960 by J.G.C. Anderson, C.T. Clough, J. Gairns, H.H. Harcourt, W. McKean, B.N. Peach, J.E. Richey, T. Robertson, W. Tulloch, K.G. Walton and P.E. Wilson.
Drift revision by J.D. Flood, P.M. Hobbs, A.E.S. Kemp and J.L. Smellie in 1980-82.
G.I. Lumsden and G.H. Land, District Geologists.
Sand and gravel survey by A.J. Shaw, A.M. Aitken and J.H. Lovell in 1982.
K.G. Thornell, Head, Industrial Minerals Assessment Unit.
1:25 000 Sand and Gravel Resource Sheet published 1983.
G.M. Brown, D.Sc., F.R.S., Director, Institute of Geological Sciences.



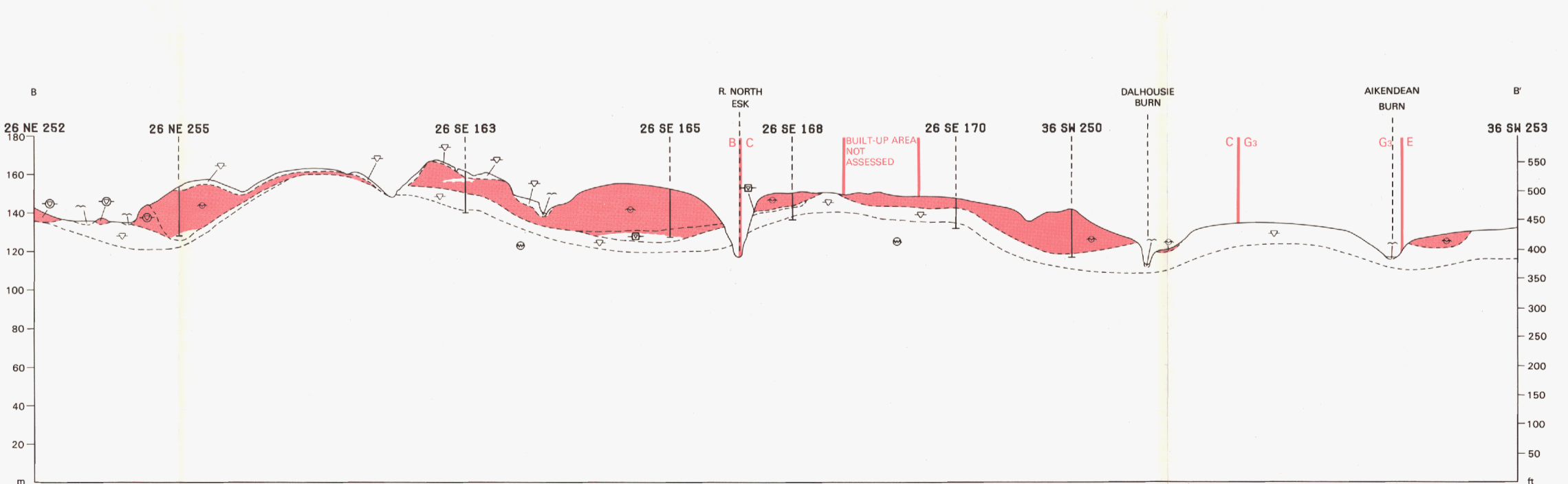
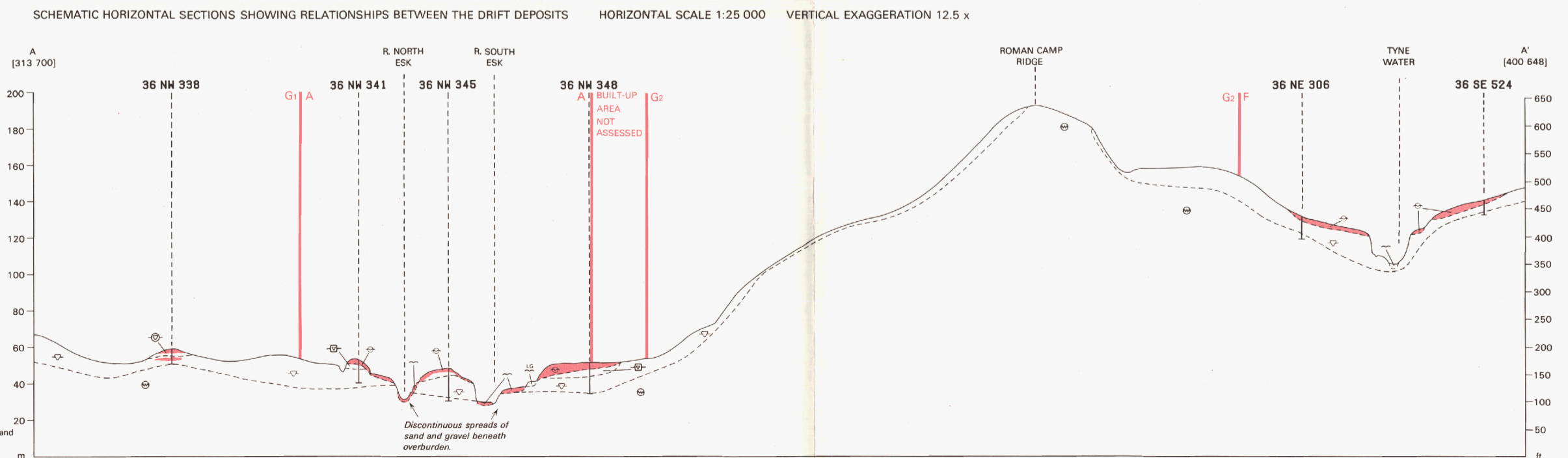
The GRID lines on this sheet are at 1 Kilometre intervals. Heights are in feet above Mean Sea Level at Newlyn. Contour values are in metres.

Data quoted for an individual sample point refer strictly to that site. Indiscriminate sampling on the ground of the thickness and grading throughout the deposit is not recommended. Reasonable estimates of volume and mass grading of the deposit as a whole is not possible unless the Resource Block is given in the Report.

NT17	NT21	NT37	NT47
NT10	NT26	NT36	NT46
		32	33
NT10	NT25	NT35	NT45
		24	25

Diagram showing the relation of the National Grid Squares to the One-Inch Geological sheets.

Borehole Graphics drawn by computer using programs written by J.L. Milnes, NERC Computing Service, Edinburgh.



CATEGORIES OF DEPOSITS

- Exposed, potentially workable sand and gravel CAT-E7
- Continuous or almost continuous spreads of potentially workable sand and gravel beneath overburden CAT-C4
- Sand and gravel not assessed CAT-N1
- Potentially workable material absent CAT-A5

RESOURCE BLOCKS
For the purposes of assessment, the mineral-bearing land is divided into Resource Blocks (see Report). Each is designated by a letter.

KEY TO SECTIONS

- Potentially workable sand and gravel, exposed or beneath overburden
- Bedrock and waste, including overburden, are unbounded
- Geological boundary
- Otherwise symbols and abbreviations as map legend

Now:
Detailed records may be consulted on application to the Office-in-Charge, Institute of Geological Sciences, Merchiston House, West March Road, Edinburgh EH9 3JA.

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140 (SOUTH)

INSTITUTE OF GEOLOGICAL SCIENCES
INDUSTRIAL MINERALS ASSESSMENT UNIT

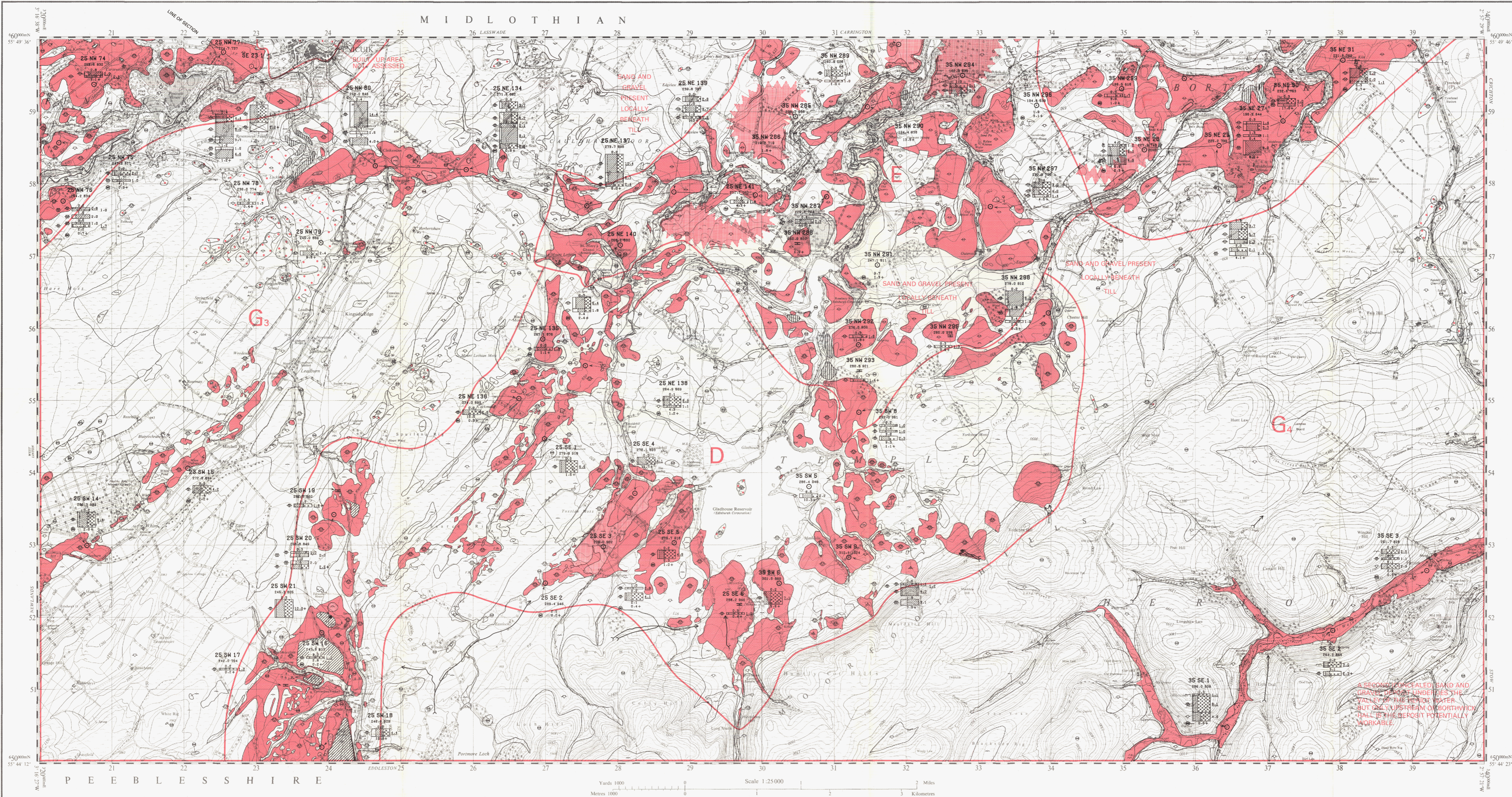
THE SAND AND GRAVEL RESOURCES OF THE COUNTRY AROUND TEMPLE, LOTHIAN REGION

Scale 1:25 000 or about 2 1/2 Inches to 1 Mile

ORDNANCE SURVEY
SHEETS NT 25 & NT 35
PROVISIONAL EDITION

THE SAND AND GRAVEL RESOURCES OF THE COUNTRY AROUND TEMPLE, LOTHIAN REGION
(SOUTHERN SHEET)

The map should be read in conjunction with the accompanying report which contains details of the assessment of resources.



EXPLANATION OF SYMBOLS AND ABBREVIATIONS

- Made ground - waste and/or natural earth materials placed on the original ground surface **MG-3**
- Made ground - waste and/or natural earth materials placed in open cast workings **MG-8**
- Landfill **L-1**
- DRIFT Quaternary
- Peat **P-1**
- Alluvium, undifferentiated - narrow floodplains and terraces generally underlain by sand and gravel, otherwise chiefly silt and clay **A-81**
- Alluvial cone - composed of sand, gravel and clay **AC-5**
- Head - stony sandy clay **H-57**
- Fluvio-glacial sand and gravel - terraced and almost flat-topped spreads of sand and gravel, generally well sorted, though clayey in part **FL-33**
- Glacial sand and gravel - mounded deposits of sand and gravel, well sorted to clay loam **GS-91**
- Glaciofluvial deposits - deposits of fine sand, silt and clay with very rare pebbles, commonly laminated (found only in boreholes) **G-7**
- Till - typically a stiff silty, sandy clay with gravel clasts up to boulder size. A thin reddish brown silty sandy clay is recognized in the areas between Temple and Carrington and Bothack and Crichton overlying the other glacial deposits **TL-21**
- SOLID Bedrock (undifferentiated) - the northern and western areas of the map are underlain by Carboniferous sediments including shales, sandstones and limestones. To the south and east Ordovician sediments of the Southern Uplands have been faulted up against the Carboniferous sediments; they include shales, sandstones, siltstones, grits and conglomerates **WG-8**
- Worked ground (sand and gravel) as at February 1982 **WG-8**

- BOUNDARY LINES**
- Geological boundary
 - Geological boundary following back-feature of terrace, downward slope in direction of arrowhead
 - Line marking back-feature of terrace, downward slope in direction of arrowhead
 - Glacial drainage channel, arrow shows direction of water flow
 - Inferred boundary between categories of deposits at surface
 - Inferred boundary between categories of deposits at depth
 - Resource block boundary

- BOREHOLE AND OTHER DATA SITE LOCATIONS**
- Industrial Minerals Assessment Unit (I.M.A.U.) borehole
 - Other borehole
 - Recorded exposure
 - Shallow pit

- I.M.A.U. BOREHOLES**
- Registration Number **25 SE 3** Surface level in metres and from datum (OS)
 - Borehole Site **Q** Surface level in metres and from datum (OS)
 - Geological Classification **L1.1** Quaternary
 - Grading Diagram **L1.1** Mineral (sand and gravel)
 - Thicknesses in metres **2.4** Bedrock

Notes:
 (i) Figures underlined denote thicknesses used in the assessment of resources.
 (ii) The '+' sign indicates that the base of the deposit was not reached.
 (iii) The Geological Classification is given only for mineral and bedrock.
Registration Number
 Each I.M.A.U. borehole is identified by a registration number, for example **25 SE 3**. The first number and letters refer to the quarter sheet and the final figures to the I.G.S. serial number for that quarter. The unique designation for borehole **25 SE 3** is **NT 25 SE 3**.
Grading Diagrams
 Each grading diagram shows the mean particle size distribution of a distinct deposit of mineral.

 The height of the diagram is proportional to the mineral thickness.
 The widths of the divisions show the proportions of **Fines, Sand and Gravel**.
 Fines: Gravel (1-75mm) (mm)

OTHER BOREHOLES
 Site investigation boreholes providing ancillary assessment data are located on the map where space permits. These boreholes are identified by serial numbers prefixed by the letters **SE**, for example **SE 21**.
SHALLOW PITS
 Where space permits the locations of shallow pits, providing ancillary assessment data are shown by a distinctive symbol. Thus: Otherwise information is shown in the same way as for boreholes.

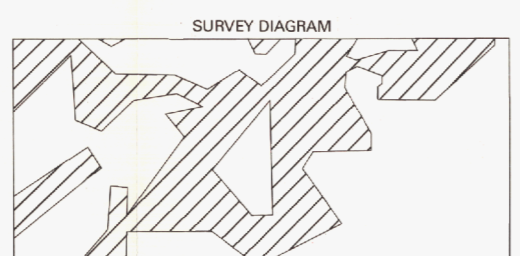
- CATEGORIES OF DEPOSITS**
- Exposed, potentially workable sand and gravel **CAT-E7**
 - Continuous or almost continuous spreads of potentially workable sand and gravel beneath overburden **CAT-C4**
 - Sand and gravel not assessed **CAT-N1**
 - Potentially workable material absent **CAT-A5**

RESOURCE BLOCKS
 For the purpose of assessment, the mineral-bearing land is divided into Resource Blocks (see Report). Each is designated by a letter.

- KEY TO SECTIONS**
- Potentially workable sand and gravel, exposed or beneath overburden
 - Bedrock and waste, including overburden, are uncoloured
 - Geological boundary
 - Otherwise symbols and abbreviations as map legend

Height in metres and feet relative to Ordnance Datum

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Geological lines taken from surveys at the six-inch scale between 1850 and 1860 by J.G.C. Anderson, C.T. Clough, J. Gair, P.H. Hovell, W. Murray, R.M. Peach, J.E. Ritchey, T. Robertson, W. Tulloch, J. Young, H.S. Walton and H.E. Wilson.
 Drift revision by J.D. Boyd, P.M. Hobbs, A.E.S. Kemp and J.H. Lovell in 1980-82.
 G.I. Lamerton and D.H. Lovell, Central Geological.
 Sand and gravel survey by A.J. Shaw, A.M. Asken and J.H. Lovell in 1980-82.
 R.G. Thornell, Head, Industrial Minerals Assessment Unit.
 1:50 000 Sand and Gravel Resource Sheet published 1982.
 G.M. Brown D.Sc., F.R.S., Director, Institute of Geological Sciences.

The area shown hatched was re-surveyed at the six-inch scale by J.D. Flood, P.M. Hobbs, A.E.S. Kemp and J.L. Spence in 1980-82. The remainder of the sheet was compiled from other geological surveys.

The GRID lines on this sheet are at 1 Kilometre intervals.
 Heights are in feet above Mean Sea Level at Newlyn.
 Contour interval is 20 feet.
 A square inch on this map represents 5000 metres on the ground.

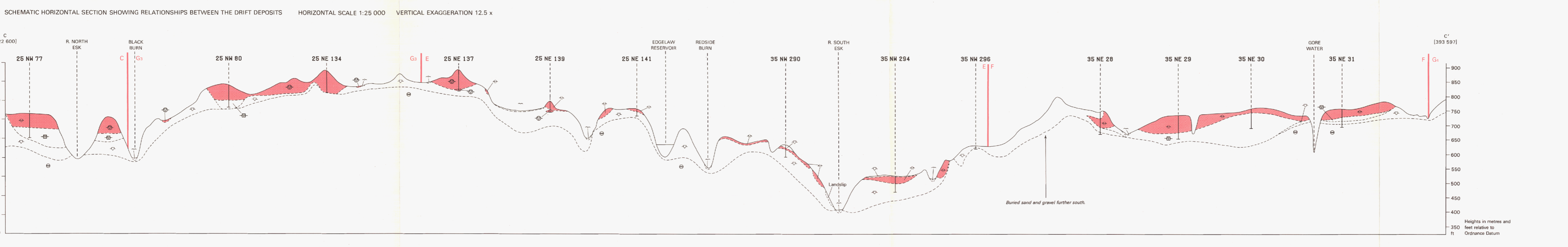
Data quoted for an individual sample point refer strictly to the site; no inferences should be drawn about the thickness and quality elsewhere on the sheet, particularly in relation to a sample of sand and gravel. Resources of sand and gravel are shown in the Report as a whole in each Resource Block as given in the Report.

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NT16	NT26	NT36	NT46
	22		33
NT15	NT25	NT35	NT45
	24		25
NT14	NT24	NT34	NT44
	24		25

Diagram showing the relation of the National Grid Squares to the One-inch Geological sheets.

Borehole Graphics drawn by computer using programs written by J.L. McIvor, NERC Computing Service, Edinburgh.



Height in metres and feet relative to Ordnance Datum

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